VOLUME 29 NUMBER 2

NEXT MONTHLY MEETING, OCTOBER 8, 1907

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

OCTOBER 1907

NEW YORK MEETING, DECEMBER 3-6, 1907

OCTOBER 1907 VOL. 29 No. 2

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
2427 YORK ROAD, BALTIMORE, MD.

EDITORIAL ROOMS
29 W. 39TH STREET, NEW YORK

Entered at the Post Office in Baltimore, Md., as second-class matter under the Act of July 16, 1894

OFFICERS AND COUNCIL

1906-1907

PRESIDENT

FREDERICK R. HUTTON .... New York, N. Y.

VICE-PRESIDENTS

Terms expire at Annual Meeting of 1907

WALTER M. McFARLAND .... Pittsburg, Pa.
EDWARD N. TRUMP .... Syracuse, N. Y.
ROBERT C. McKINNEY .... New York, N. Y.

Terms expire at Annual Meeting of 1908

ALEX. DOW .... Detroit, Mich.
P. W. GATES .... Chicago, Ills.
J. W. LIEB, JR. .... New York, N. Y.

PAST PRESIDENTS

Members of the Council for 1906-1907

JAMES M. DODGE .... Philadelphia, Pa.
JOHN R. FREEMAN .... Providence, R. I.
EDWIN REYNOLDS .... Milwaukee, Wis.
AMBROSE SWASEY .... Cleveland, O.
FREDERICK W. TAYLOR .... Philadelphia, Pa.

MANAGERS

Terms expire at Annual Meeting of 1907

GEO. M. BRILL .... Chicago, Ills.
FRED J. MILLER .... New York, N. Y.
RICHARD H. RICE .... Lynn, Mass.

Terms expire at Annual Meeting of 1908

WALTER LAIDLAW .... Cincinnati, O.
FRANK G. TALLMAN .... Wilmington, Del.
FREDERICK M. PRESCOTT .... Milwaukee, Wis.

Terms expire at Annual Meeting of 1909

A. J. CALDWELL .... Newburg, N. Y.
G. M. BASFORD .... New York, N. Y.
A. L. RIKER .... Bridgeport, Conn.

TREASURER

WM. H. WILEY .... New York, N. Y.

SECRETARY

CALVIN W. RICE .... 29 West 39th Street, New York, N. Y.

CHAIRMAN OF FINANCE COMMITTEE

E. D. MEIER .... New York, N. Y.

Proceedings is published twelve times a year, monthly except in July and August, semi-monthly in October and November.

Price, one dollar per copy—fifty cents per copy to members. Yearly subscription, $7.50; to members, $5.

PROCEEDINGS

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 29 OCTOBER 1907 NUMBER 2

An address on "College and Apprentice Training," treating of the relation of the student engineering courses in the industries to the college technical courses, by Professor John Price Jackson of State College, Pa., is published in this number. This address will be delivered before the Society at its monthly meeting, Tuesday Evening, October 8, at 7:45 o'clock. Dr. Henry S. Pritchett and Prof. Dugald C. Jackson will contribute to the discussion of the subject. Impromptu discussions from members, who, after hearing the facts presented, desire to comment upon them or to offer experiences, will be invited.

This is a subject in which manufacturers are greatly interested and the Society is making a special effort to make this meeting a "common" where opinions will be freely exchanged.

CONSOLIDATION OF THE MECHANICAL ENGINEERS' LIBRARY ASSOCIATION WITH THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

General attendance at the Otcober 8 meeting of the Society is desired on account of the votes on the merging of the Mechanical Engineers Library Association into The American Society of Mechanical Engineers.

The proposed merger has been considered and approved by the officers of the two corporations.

THE NOVEMBER MEETING

The attention of the members is called to the paper on "A High Speed Elevator" by Mr. Charles R. Pratt, which appears in this num-

ber. It treats of the Gearless 1 to 1 Traction Electric Elevator which is to be installed in the building of the Metropolitan Life Insurance Company and in the new Singer building. It gives a description of the elevator and takes up impartially its advantages and defects.

Discussion is invited from all who are interested in elevators.

THE ANNUAL MEETING

The program of the Annual Meeting, December 3–6, will be given in the Mid-October Proceedings. The sessions will be planned with an idea of providing papers on various subjects, so as to be interesting to engineers in many lines of mechanical work.

At least two sessions will be devoted to gas power and foundry practice, and several papers on miscellaneous subjects of pertinent interest will be scheduled. All papers presented will be published in the pre-convention issues of Proceedings, the last of which will appear November 15. This will give members an opportunity to read and study the papers they wish to discuss.

PAPERS FOR THE ANNUAL MEETING

Articles for the Annual Meeting in December will be received up to October 15. A later date will not permit publication before the convention. No further notice will be given.

Authors are expected to personally present papers. When an author can not attend he should send a representative.

DISCUSSION

Attention is called to R 7, which provides that each speaker at the meeting is limited to five minutes for oral discussion, and that ten minutes is allowed for the written remarks. The reason for this is obvious, and the Society urges, for the mutual benefit derived, that members, as far as possible, prepare their discussions before the meeting. Less time is taken for the data presented, and the results are more satisfactory. It is desired, however, that they contribute freely to discussion. The point we wish to make is that it should be condensed as far as the actual data presented will permit.

THE MECHANICAL ENGINEERS LIBRARY ASSOCIATION

At a meeting of the Board of Trustees of The Mechanical Engineers' Library Association, Mr. Fred. W. Taylor, Past President, was

appointed to fill the unexpired term of Admiral Charles Harding Loring, deceased.

THE JURY OF AWARDS—JAMESTOWN EXPOSITION

Several members of this Society, Prof. Gaetana Lanza, Prof. R. C. Carpenter, and Messrs. James M. Dodge, B. V. Swenson and John Birkinbine are serving on the Jury of Awards of the Jamestown Exposition.

The Jury is composed of about seventy-five of the most eminent men in the professions which they represent. Mr. Ambrose Swasey, past president of the Society, is vice-president and is engaged in the administrative work of the Jury.

We are pleased to chronicle the broad minded interest of the Society in public engineering affairs which is exemplified in the contribution of valuable time by busy men to the requirements of the engineering world.

"ON THE ART OF CUTTING METALS"

The Presidential address by Mr. Fred. W. Taylor, read before the New York meeting of last year, has been translated into the French by Mr. C. Codron of Paris, and is now appearing serially in the "Revue de Mécanique," the first installment appearing in the issue of July 31 this year.

The book entire is about to be published in German by Julius Springer and Company, Berlin, the translation being made by Prof. A. Wallich of Aachen.

An abstract of this address by Prof. A. Wallich and Dr. O. Peterson appeared in "Stahl and Eisen," beginning July 17, 1907.

It is a cause for congratulation that this article was presented under the auspices of the Society and the influence of the work of the Society on the American and European public cannot be overestimated. Engineers at home and abroad have universally joined in praise of President Taylor's work, carried on during so many years, being a complete statement to date of the advancement in the art of cutting metals.

This complete work in English of 248 pages and 150 tables and illustrations may be obtained from the Society at a nominal price; only the cost of production has been placed on it as it is the gift of a life work by the author and is intended to be a hand book in every shop.

OBITUARIES

PETER E. LE FEVRE

Peter E. Le Fevre was born at Brooklyn, N. Y., on November 26, 1841. After receiving his education he became a marine engineer. He was chief engineer of the following steamships: The North America, South America, Matanzos, Merrimac, Herman Livingston, City of Macon, City of Columbus, and Tallahassee.

From 1887 to his death he was superintending engineer of the Ocean Steamship Company and the Canada and Atlantic Steamship Company, being responsible for all work on steamers and docks.

Mr. Le Fevre became a member of the Society in 1895. He died in New York, November 19, 1906.

FREDERICK BROTHERHOOD

Frederick Brotherhood was born in England in 1845 and was educated at private schools.

Later he entered Rowland Brotherhood Railway Works, Chippenham, England, working in the different departments, drawing office, shops, construction of bridges, railroad fittings and rolling stock, locomotives and general engineering, and later assisted in the building of various railroads and executing contracts.

He was superintendent of the Wilkesbarre Shops of the Dickson Manufacturing Company two years, with the Charleston Iron Works, Charleston, S.C., in the designing and construction of boilers, engines and cotton compresses, six years, and since, as consulting engineer, he has designed and built various factories, dredges and dock gates. He operated successfully for many years one of the largest phosphate dredges ever built. Mr. Brotherhood died November 15, 1906, at Bridgeport, Conn.

CHAS. K. STEARNS

Chas. K. Stearns died in the city of Boston, May 12, 1907. He was born at Newton Centre, Mass., in 1864 and educated in the Newton public schools, and at the Massachusetts Institute of Technology, graduating in 1887. He was engaged by the Thomson-Houston Electric Company at Boston and later was manager at their St. Paul

office. He was assistant engineer in electrifying the Nantasket Beach branch of the New York, New Haven and Hartford Railroad, and during his later years had continued in similar work with street railways and the electric development of water powers. Mr. Stearns joined the Society in 1899.

WILLIAM L. SIMPSON

William L. Simpson was born in Philadelphia, March 25, 1847, and spent his early life in Chester, Pa., serving an apprenticeship with the firm of Reany, Son and Archbold. He was engaged in the merchant marine service for several years, during which time he was engineer on the steamer Juanita of the Southern Mail Steamship Company, off the Coast of Florida Keys in 1870. Later he was connected as erecting engineer with the Scott Foundry of Reading, Pa., and for four years was superintendent of the Dickson Manufacturing Company in Wilkesbarre, remaining with them until 1877, leaving there to take charge of the Baine and Huston Works in Philadelphia. He was associated with the Buckeye Engine Company of Salem, Ohio, and organized a shop in Philadelphia in 1880 for the manufacture of engines for the eastern market. Afterwards he became general Eastern sales agent for the Buckeye Engine Company. Mr. Simpson joined the Society in 1890. He died February 1, 1907.

PETER WILLIAM LÜDERS

Peter William Lüders was born March 22, 1872 in Schleswig-Holstein, Germany. He began practical work early, his first mechanical experience being gained in the machine shops of the Berliner Maschinenbau Artiengesellschaft. In 1891 he entered the Polytechnical High School at Carlsruhe. In March 1899 he left Berlin and came to the United States with the purpose of making a special study of American machine shop practice, spending several months in some of the most important shops. He was elected an Associate Member of The American Society of Mechanical Engineers in November 1899; was a contributor of articles to the Engineering Magazine on American machine shop practice from a German view point. After his return to Berlin in the year 1901 Mr. Lüders became a member and general superintendent of the Berlin Erfurter Maschinenfabrik Henry Pels and Company. The success of his work in bringing the shops up to date for the manufacture of the punching and shearing machines of the Berlin Erfurter Maschinenfabrik is due to his untiring energy and perseverance.

Mr. Lüders died June 30, 1906.

JAMES ROWAN

James Rowan was born in Glasgow on March 18, 1854. He was educated at the Glasgow Academy and the Glasgow University, serving subsequently an apprenticeship of five years (from 1870 to 1875) in the pattern shop, the fitting department and the drawing office of his father's works. In 1880, he became assistant manager, and five years later was made a partner, the title of the firm becoming David Rowan and Son. In 1888 he assumed complete control of the establishment. He evolved the Rowan premium system applied to shop management and delivered addresses before several engineering conferences on works organization and labor remuneration.

Mr. Rowan took an active and useful part in many engineering organizations. He was a member, sometime a vice-president, and at the day of his death a member of the Council of the Institution of Mechanical Engineers. He was a member of the Northeast Coast Institution of Engineers and Shipbuilders, and was president for the current year of the Northwest Engineering Employers Association.

Mr. Rowan died November 19, 1906.

EDWARD PAYSON BULLARD

Edward Payson Bullard was born August 18, 1841, in Uxbridge, Massachusetts. After the completion of his apprenticeship at the Whitin Machine Works, Whitinsville, Mass., until 1863 he was connected with the Colts Armory in Hartford, Conn., after which he entered the employ of Pratt and Whitney, and later formed the partnership of Bullard and Prest, Machinists of Hartford. In 1866 Mr. Bullard organized the Norwalk Iron Works Company of Norwalk, Conn., but afterwards withdrew and continued the business in Hartford. In 1868 the firm of Bullard and Prest dissolved and Mr. Bullard became superintendent in a large machine shop at Athens, Georgia. Later he became connected with the Cincinnati branch of Post and Company, organizing their machine tool department.

In 1872 he was made general superintendent of the Gill Car Works, Columbus, Ohio: in 1875 established himself in the machinery business on Beekman Street in New York, under the firm name of Allis, Bullard and Company and in 1877 the Bullard Machine Company was organized. In 1880 Mr. Bullard secured entire control of the business. Later in the same year he became the owner of the Bridgeport Machine Tool Works. In 1883 he designed a 37 inch vertical boring and turning mill with single head and belt feed, which is believed to be the first small mill of this type.

The Bridgeport Machine Tool Works was incorporated in 1894 under the name of the Bullard Machine Tool Company, with which Mr. Bullard was connected at the time of his death, December 22, 1906.

SIR BENJAMIN BAKER

Sir Benjamin Baker was born at Tondu, Glamorganshire, March 31, 1840. At sixteen years of age he was apprenticed to the North Abbey Iron Works, South Wales, remaining with them four years. On leaving these works he aided in the erection of the Victoria Station and the Governor Road railway bridge. Upon the proposal of Sir John Fowler to construct an underground Railway, which was received with great opposition, Mr. Baker spent much time in the study of theoretical mechanics which resulted in his work on "Long Span Bridges" and "The Strength of Beams" published in "Engineering" (London). In the former article the possibilities of the Cantilever type of bridge with a central supported girder, worked out in later years in the Forth Bridge, first received recognition. He was the author of several articles on "The Strength of Brickwork" published in 1872, and "Urban Railways" published in 1874. He was engineer of the City and South London Railway, the first of the underground lines in London. He had complete control of constructing the District line from Westminster to London. In conjunction with the contractor he designed the cylindrical iron vessel in which Cleopatra's needle was transported to England in 1878.

One of the existing monuments to his work is the design and construction of the Forth Bridge in which he carried out the theories set forth in his articles on "Long Span Bridges." While engaged in this work he made a series of experiments on the mechanical properties of structural steel which had an influence in England on the proportioning of structural steel. He pointed out the necessity of using a lower unit stress on bars subject to alternating strains and called the attention of England to the standards of safety observed by the German Government and American engineers which was 60 per cent higher than that demanded by the British Board of Trade.

The firm composed of Sir John Fowler and Sir Benjamin Baker was sought after for advice upon the important engineering projects of the time and all the early tube railways had the benefit of their services. They were the engineers for the Central London Railway, where they carried out their design of locating the station on the summit of an incline. with the result that a reasonably high speed for a city railway was for the first time obtained.

Sir Benjamin was consulting engineer for the Baker-Street and Waterloo Railway and he also designed for the Hudson River tunnel a special form of shield fitted with diaphragms dividing the whole up into compartments, each of which could, in case of necessity, be used as a diving bell.

The greatest work accomplished by Sir Benjamin Baker was the Assonan Dam on the Nile. The proposal of its construction met with great opposition on account of the danger to the Temples of Philæ. The question was referred to an International Commission of which Sir Benjamin was the English representative. The construction was authorized, Sir Benjamin taking the entire responsibility for the work. Upon its successful completion he was created a Knight Commander of the Bath and was also honored upon this occasion by the Khedive. The latter part of his life was devoted to the study of a system of reinforcements and additions which will enable the reservoir to be doubled. His design was adopted by the Egyptian Government. He advised with the London authorities in regard to the construction of a railway bridge across the Blue Nile into Khartoum, and signed the plans just before his death for a bridge across the Nile at Boulac, the port of Cairo, where the river is 900 feet wide, the main channel 80 feet deep, and the river bed of sand and gravel.

Sir Benjamin was joint engineer with Sir John Wolfe Barry for the Avonmouth Docks and was engineer for the Walney Bridge, of the Barrow-in-Furness Railway, which is 1100 feet between abutments and has an electrically operated opening span on the Scherzer principle. He was appointed consulting engineer on the West African Railways and served in the same capacity for the Public Works Department of Cape Colony.

At the time of his death he was engaged in widening from 80 to 100 feet the Buccleugh Dock entrance at Barrow and in replacing the swing bridge with one of the roller lift principle. He was also engineer to the Rosslere and Waterford Railway, opening up the new route to the South of Ireland.

Throughout his career Sir Benjamin took a keen interest in the scientific societies associated with his profession. He was member of the Institution of Civil Engineers; a member of Council in 1882; vice-president in 1891, and president in 1895. He was president of the Mechanical Science Section of the British Association; Fellow of the Royal Society, and at the time of his death was vice-president of that body. He was a member of the Institution of Mechanical Engineers, and served for many years as a Member of the Council, being in office at the time of his decease. Up to the last, he took a very

active interest in the affairs of the Royal Institution. He was an honorary member of the American Society of Civil Engineers, the American Society of Mechanical Engineers and honorary degrees were conferred upon him by the Universities of Cambridge and Edinburgh. He was made a Knight of the Order of St. Michael and St. George at the opening of Forth Bridge. He was a member of the Engineering Standards Committee, serving on the Finance Committee, and as chairman of the Sectional Committee on Bridges and Building Construction. The valuable specifications for structural steel issued by the latter Committee owed him much.

His death occurred May 19, 1907 at his residence, Bowden Green, Pangbourne. The remains were interred at Idbury, and Memorial Services were held at St. Margaret's, Westminster, on the same day.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both as to positions and as to men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up entirely of members of the Society and these are on file, with the names of other good men, not members of the Society, capable of filling responsible positions, information about whom will be sent upon application.

POSITIONS AVAILABLE

071 Manufacturing concern requires the services of a superintendent able to take entire charge of the manufacturing end of the business, preferably a man who has had experience in light metal work. Must be able to furnish highest references. State salary expected. Location New York.

072 Foremanship of a manufacturing plant. Work demands a strictly up-to-date foundry foreman who is familiar with the melting of irons and intricate core work. Location Illinois.

073 Several young men to teach drawing and machine design in evening classes. Location in Greater New York. Will pay $2.50 to $3.00 an evening, from 7.30 to 9.30, Monday, Wednesday and Friday Evenings.

074 Mechanical engineer. capable of doing testing work and of devising systems of economical operation of the several mechanical departments of a Colorado concern. Applicant should state fully, past experience especially along the line of boiler tests, design of steel structural work, etc.

075 Assistant professor experimental engineering for college in the Middle West. Salary $1200 a year. Laboratory, class room and departmental work.

076 An assistant professor in mechanical engineering to assist in regular departmental work, make drawings and class room illustrations. Location in the Middle West. Salary $60 to $90 a month according to experience.

MEN AVAILABLE

125 Mechanical engineer; industrial engineering negotiations, designing, purchasing and erection.

126 Junior, graduate Pennsylvania, three years experience with steam boilers and distilling apparatus, desires position in connection with steam engineering work.

127 Technical graduate, Rensselaer Polytechnic, experienced as superintendent of construction, on concrete, reinforced concrete, heavy timber work, piers and dry-docks; general construction experience; at present engaged in similar work and will be available by Nov. 1, but if necessary could arrange to leave present position on about two weeks notice. Married; 36 years old. Salary $150 to $200 according to location.

128 Member, 46 years of age, technical graduate, desires position; experience recently has been largely in the office of small machinery manufacturing house; has acted as secretary and treasurer, taken care of correspondence and buying and selling.

129 Member, graduate of Stevens Institute with several years experience in consulting work; recently chief engineer of an organization employing some twenty engineers and draftsmen, would like position with manufacturing concern desirous of decreasing operating expenses.

130 Superintendent, technical graduate, of 12 years practical experience in field, shop and drafting room, desires position with some manufacturing concern in the Middle States.

131 Associate member, mechanical engineer, will be open for position about Oct. 15, 1907. Specialty, mechanical engineering of mines and smelters, and construction engineering. At present assistant chief engineer of one of the largest mining, smelting and refining companies in the country. Technical education, shop, drawing room and field experience. Western location desired although power plant work in east would be considered.

132 Junior member experienced in reinforced concrete design and estimating, also concrete fire-proofing; desires position, as present company is going out of business.

133 Mechanical engineer wants engagement. Specialty, design and installation of electric railways and power stations, familiar with building construction, foundations and hydraulic work.

134 Draftsman, representative salesman or assistant superintendent along mechanical lines; near New York.

135 Superintendent, long experience in various lines. Recently in charge tool design and special machine work.

136 Member, graduate of Lehigh University, mechanical engineer. Sixteen years practical experience; two years in anthracite coal region, and fourteen years with steel company—engineering and manufacturing branches. Would like to connect with an established concern where ability and hard work will be recognized.

137 Power plant construction and installation. Steam turbine expert.

CHANGES OF ADDRESS

ASHWORTH, Albert Kennedy (Junior, 1897) M. E. Pittsburg Gage & Supply Co., 30th and Liberty Ave., Pittsburg, and for mail, 67 Ridge Ave., Crafton, Pa.

BISHOP, Frank (Associate, 1907) Charge of Mach. Shop and Millwright Dept., Singer Mfg. Co., and for mail, 1241 Mich. Ave., South Bend, Ind.

BOUGHTON, Judson H. (Junior, 1903) National Light and Improvement Co., Pierce Bldg., St. Louis, Mo.

BUNNELL, Sterling Haight (1894; 1903) Griscom, Spencer & Co., 90 West St., New York, N. Y.

BURNHAM, Harry A. (1898; 1902) Ridgewood Terrace, Waltham, Mass.

BUTCHER, Joseph J. (1892) Guiler-Gordon Engineering Co., 442 Board of Trade Bldg., 10 Broad St., and for mail 195 West Brookline St., Boston, Mass.

CHRISTENSEN, August C. (1880) 545 West 147th St., New York, N. Y.

CLEGG, Robert I. (1902) Editor, "Castings," Caxton Bldg., and 2105 East 81 Pl., Cleveland, O.

COLE, Dwight S. (1903) Engrg. Dept., Olds Motor Works, and for mail, 121 Shiawassee St., E., Lansing, Mich.

CONLEE, George D. (Junior, 1906) 402 Eddy St., Ithaca, N. Y.

COOK, E. J. (1891) Rochester Railway Co., 267 State St., Rochester, N. Y.

COOK, Thos. Fowke (Junior, 1904) 154 East 37th St., New York, N. Y.

CRAMP, Edwin S. (1888) Spring Lake, N. J.

DEAN, Arthur Malcomb (Junior, 1907) Mora Motor Car Co., and for mail, 49 Church St., Newark, N. Y.

DOUD, Arthur T. (Junior, 1907) Engr., Gunn, Richards & Co., 43 Exchange Pl., New York, N. Y.

EKSTRAND, Charles (1898; 1903) 516 West 140th St., New York, N. Y.

FERNALD, Robt. H. (1900; 1903) Prof. Mech. Engrg., School of Applied Science, Cleveland, O.

GLASGOW, Carr L. (Junior, 1904) Sales Dept., Allis Chalmers Co., Montreal, Canada.

GRAY, John Lamont (Associate, 1904) Baldwin & Gray Engrs., Williamstown, Melbourne, and for mail, 9 Esplanade Williamstown, Victoria, Australia.

GRIFFITHS, Leonard L. (Junior, 1905) Supt. United States Cement Co., Bedford, Ind.

HANSON, Walter S. (Associate, 1902) 4 West 37th St., Kansas City, Mo.

HENRY, George J. Jr. (1901) Chief Engr., The Pelton Water Wheel Co., 19th and Harrison Sts., and 2028 Broderick St., San Francisco, Cal.

HUTCHISON, Arthur H. (1899) Western Mgr., De La Vergne Machine Co., 712 Wainwright Bldg., St. Louis, Mo.

JACKSON, Wm. B. (1901) Life Member, D. C. & Wm. B. Jackson, Cons. Engrs., Commercial Natl. Bank Bldg., Chicago, Ill.

JENKINS, Alexander Lewis (Junior 1907) Instr., Mech. Engrg., University of Cincinnati, Cincinnati, Ohio.
KEELY, Royal R. (1901; 1907) City Engr., Edmonton, Alberta, Canada.
KELSEY, Walter (Junior, 1900) 801 Marion St., Seattle, Washington.
LANE, Henry Marquette (1900) Editor, "Castings" and Secy., The Foundry Supply Asso., 1137 Schofield Bldg., Cleveland, O.
LARNER, Chester W. (Associate, 1907) 8707 Carnegie Ave., Cleveland, O.
LENT, Leon B. (1905) N. Y. Mgr., Riverside Engine Co., 26 Cortlandt St., New York, N. Y.
LOWE, William Voss (1889; 1892) 8 Charming Street, Worcester, Mass.
McMULLIN, Frank Van (1903) 1301 Walnut St., Edgewood Park, Pittsburg, Pa.
MANSFIELD, Albert K. (1887) Cons. Engr., 283 Lincoln Ave., Salem, O.
MASSA, Robert F. (1904) Creamery Package Mfg. Co., and for mail, 221 Ewing St., Chicago, Ill.
MORGAN, Ralph Landers (1900; 1902) 21 Lincoln St., Worcester, Mass.
MORLEY, Ralph (Junior, 1906) 63 South 10th St., Brooklyn, N. Y.
MUNBY, Ernest J. (1906) Engr. and Dir. Auriferous Pyrites By-Products Co., Asst. Supt. Mech. Dept., S. Pearson & Son (inc.) Contractors for Penn., N. Y. & L. I. R. R. East River Tunnels, 146 East 36th St., and Baddon Park, Essex, England, and for mail, 306 West 80th St., New York, N. Y.
PALMER, Virgil Maro (Junior, 1905) Nordyke & Marmon Co., Indianapolis, Ind., and 144 Pleasant St., Willimantic, Conn.
PENNINGTON, James H. (1902) Room 1047, 42 Broadway, New York, N. Y.
PERKINS, Geo. H. (Associate, 1907) head of Textile Engrg. Dept., Lowell Textile School, Lowell, Mass.
PITKIN, Jos. Lovell (Associate, 1903) The Lane Mills, New Orleans, La.
ROGERS, Fred. E. (Associate, 1907) Editor, "Machinery" and "Railway Machinery," 49–55 Lafayette St., New York, N. Y., and for mail, 6 Garfield Pl., East Orange, N. J.
SCHAEFFER, Simon (Junior, 1904) B. S. Harrison, 11 East 24th St., and 362 West 121st St., New York, N. Y.
SCHNEBLE, Rudolph G. (1897) Mech. Engr., 24 N. Harshman St., Dayton, O.
SCHWARTZ, Carl (1906) Engr. of Power Sta., N. Y. C. & H. R. R. R. Co., Grand Central Sta., Room 1231 and 2100 Fifth Ave., New York, N. Y.
SCOTT, James B. (1896; 1900) Cons. Engr., Maryland Savings Bank Bldg., and 2011 Bolton St., Baltimore, Md.
SELLS, Osborn P. (1902) Kearney, Neb.
SEWALL, Minott W. (1899) Supt., Engrg. Dept. Babcock & Wilcox Co., 85 Liberty St., and 222 4th Ave. W., Roselle, N. J.
SICKLES, Eugene Charles (1896; 1904) Mech. Engr., New Baltimore, N. Y.
SIRICH, J. Henry, Jr. (Associate, 1907) 3011 Clifton Ave., Baltimore, Md.
SYMONDS, Nathaniel Gardner (Junior, 1905) 27 West 27th St., Indianapolis, Ind.
TOWLE, Wm. Mason (1887) Life Member, Supt. of Shops, Clarkson Memorial School of Technology, and for mail, 27 Main St., Potsdam, N. Y.
WALLIS, James T. (1901), Present address unknown.
WEBER, Frederick C. (Associate, 1895) Mech. Engr., Engineers' Club, 32 West 40th St., New York, N. Y.
WILCOX, Wallace J. (1891; 1893) Mech. Engr., Winslow, Arizona.

WILDIN, George H. (1901) Mech. Supt., N. Y. N. H. & H. R. R., New Haven, Conn.

WILSON, Hugh H. (1907) Asst. Supt., The Ontario Power Co. of Niagara Falls, P. O. Box 4, Niagara Falls, N. Y.

WRIGHT, Royden V. (1907) Managing Editor, "American Engineer and Railroad Journal," 140 Nassau St., New York, N. Y., and for mail, 285 North 20th St., East Orange, N. J.

NEW BOOKS.

HAND BOOK OF AMERICAN GAS ENGINEERING PRACTICE. By M. Nisbet-Latta. *D. Van Nostrand & Co., New York. 1907.* 8vo, Cloth \$4.50.

Contents by chapter headings: Part 1, Water-Gas Manufacture; The Generator; the Carburetter; the Superheater; Wash-Box and Tar; Scrubbers; Condensers; Purifiers; Exhausters; Station-Meters; Molders; Details of Works Operation. Part 2, Gas Distribution; Naphthalene; Mains; Services; Consumers' Meters; House Piping; Appliances. Part 3, General Technical Data; Properties of Gases; Steam; Mathematical Tables; Conversion Factors; Pipe and Miscellaneous Data.

AMERICAN PATTERN SHOP PRACTICE. By H. J. McCaslin. *Frontier Publishing Co., Cleveland, O. First Edition, 1907.* 8vo, 273 p. Cloth.

Contents by chapter headings: Engine Patterns; Molding and Cores; Sweep Work; Gearing; Representative Patterns; Hints, Suggestions and Rigs.

BUSINESS FEATURES OF ENGINEERING PRACTICE. Lecture Notes. By Alexander C. Humphreys. Also Supplement No. 1, Commercial Law. By H. E. White. *Stevens Institute of Technology, 1905.* 8vo, Cloth \$1.25.

THEORY AND PRACTICE OF MODERN FRAMED STRUCTURES. By J. B. Johnson, C. W. Bryan and F. E. Turneaure. *New York, 1906.* 4vo, 551 p. Cloth \$10.

PRODUCER GAS. By J. Emerson Dowson and A. L. Larter. *London, 1906.* 8vo, 73 illus. 309 p. Cloth \$3.

ETUDES SUR L'ORGANIZATION DU TRAVAIL DANS LES USINES. Par F. W. TAYLOR. *La Revue de Métallurgie. Angers, 1907.*

Contents by chapter headings: Première Partie ; La Taille des Métaux. Deuxième Partie: L'emploi des Courroies. Troisième Partie: La Direction des Ateliers.

ENGINEERING STANDARDS COMMITTEE. Report on British Standard Systems. Limit Gages for Screw Threads. *No. 38. 1907.*

ENGINEERING STANDARDS COMMITTEE. Report on copper alloy bars. for use in automatic machines. British Standard Specifications. *London, 1907.*

AMERICAN SOCIETY OF CIVIL ENGINEERS. *Transactions. Vol. 58. June 1907.*

COLD STORAGE AND ICE ASSOCIATION. *Proceedings. Vol. 72. 1906–1907.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings. *Vol. 168. Part. 2. 1906–1907.*

IRON AND STEEL INSTITUTE. *Journal. Vol. 73 and 74. No. 1 and 2, 1907.*

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS. *Transactions. No. 82. 1907.*

JAHRBUCH FÜR DAS EISENHUTTENWESEN. By Otto Vogel. *1904. Düsseldorf, 1907.*

FIRE TESTS WITH GLASS. *"Red Books" of the British Fire Prevention Committee. No. 116. London, 1906.*

NATIONAL FIRE PROTECTION ASSOCIATION. Eleventh Annual Meeting. *May 1907.*

NAVAL INSTITUTE. *Proceedings. Vol. 33. No. 2. June 1907.*

NEW ENGLAND WATER WORKS ASSOCIATION. *Vol. 21. No. 2. June 1907.*

ROCKS FOR ROAD BUILDING. U. S. Dept. of Agriculture. Office of Public Roads. *Bulletin 31. 1907.*

WESTERN SOCIETY OF ENGINEERS. *Journal. Vol. 12. No. 3. June 1907.*

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. *Proceedings. Vol. 26. No. 6. June 1907.*

AMERICAN INSTITUTE OF MINING ENGINEERS. *Transactions. Vol. 37. 1907.*

AMERICAN SOCIETY OF CIVIL ENGINEERS. *Proceedings. Vol. 33. No. 6. August 1907.*

AMERICAN SOCIETY OF NAVAL ENGINEERS. *Journal. Vol. 19. No. 2. May 1907.*

BUREAU OF LABOR DEPARTMENT OF COMMERCE AND LABOR. *Bulletin No. 70. May 1907.*

ANNUAL CONVENTION OF AMERICAN ARCHITECTS. *Proceedings. 1906.*

ENGINEERS SOCIETY OF WESTERN PENNSYLVANIA. *Vol. 23. No. 5. June 1907.*

ENGINEERING DEPARTMENT OF NATIONAL ELECTRIC LAMP ASSOCIATION. *Bulletin. No. 1.*

EXTENSION OF THE DEWEY DECIMAL SYSTEM OF CLASSIFICATION APPLIED TO ARCHITECTURE AND BUILDING. Dy N. Clifford Ricker.

BULLETIN OF THE UNIVERSITY OF ILLINOIS ENGINEERING EXPERIMENT STATION. *Urbana, Ill. 1907.*

INGENIEURS CIVILS DE FRANCE. *Bulletin. May 1907.*

MOLDING SAND

The Improvement of Molding Sand by Mechanical Treatment

By ALEXANDER E. OUTERBRIDGE, JR., PHILADELPHIA, PA.
Non-Member

It is no exaggeration to say that foundry practice, in this country at least, has been revolutionized within the past twenty-five years through the substitution of scientific for empirical methods.

2 The relation between the chemical composition and physical properties of metallic alloys used in founding — thanks to the pioneer investigations of Professor Turner and others — is now very generally known, and practical application is made of this knowledge in all modern plants.

3 Next in importance to the various metals of which castings are made, if not indeed of equal importance therewith, must be classed the material of which the molds and cores are composed. Strange to say, there is comparatively little literature dealing with this important topic in a scientific way and that little is found in technical magazines and in the Proceedings of the Engineering Societies. It remains for some one to collate the facts and to present them in a form available to the founder.

4 The writer having been invited to contribute a paper to a symposium upon the subject of molding sand and its treatment will confine his remarks to the practical side of the question and endeavor to show how greatly molding sand, including core sand, can be improved

To be presented at the New York Meeting (December 1907) of The American Society of Mechanical Engineers, and to form part of Volume 29 of the Transactions.

in its physical properties by correct mechanical treatment; and at the same time, how the cost of preparation of the sand for molds and cores can be greatly reduced as compared with the old fashioned methods that are still in vogue in many establishments.

5 In the effort to prevent costly "wasters" in the foundry, which sometimes wipe out the estimated profit on some specific jobs, the composition and physical properties of the different varieties of molding sand used in the foundry of William Sellers & Co. Incorporated, first became the subject of careful study by the writer more than fifteen years ago.

6 The selection of sand suitable for all purposes in the foundry constituted at that time a not unimportant part of the duty of the very competent foundry foreman.

7 It was found on looking into the matter that the only tests — if tests they could be called — which were then made of new sand were two in number and exceedingly crude in kind, one being for "toughness," a most important, indeed essential property, the other for "porosity."

8 The expert's test for toughness consisted simply in squeezing a handful of the sand into the form of a ball and then breaking it, little or no attention being paid, by the way, to the degree of dampness or the more or less heterogeneous composition of the sand. The porosity test consisted, in like manner, in compressing gently a small quantity of the sand between the palms of the hands and then blowing through it. While such tests may seem absolutely absurd in their crudity it must be admitted that in the hands of an expert they afford a fair degree of practical knowledge of the average quality of the molding sand.

9 In order to improve, if possible, on these time honored methods of testing sand, the first plan devised was to make a number of test bars of "green" sand, 6 by 1 by 1 inches, under uniform conditions of pressure, dampness, and quantity of material used in forming the molds. These little test bars were placed upon a smooth metal plate with sharp and square edges. The bars were then pushed over the edge of the plate, until they broke when the amount of the "overhang" was measured. It was soon found that there was a great difference in the length of the overhang, which was regarded as a quantitative measure of toughness of the sand; these differences were not even noticeable by the crude ball test.

10 Samples taken from different parts of a small heap of sand that had been uniformly dampened or "tempered," varied greatly in this respect, owing, no doubt, to the irregular distribution of the alumina

or clay binder, and the correctness of this inference was subsequently confirmed by simple analytical tests.

11 After a sufficient number of these test bars had been made and broken to prove the reliability of the method, further tests were devised to ascertain whether the usual methods of riddling and mixing sand for the molder's use affected its quality either by increasing or decreasing its toughness, as shown by the amount of overhang of similar test bars of green sand. It was proved that the more thoroughly the sand was worked the greater the overhang, due as already stated to the more uniform distribution of the binder.

12 The ideal molding sand is a material in which the individual grains of silex, constituting approximately 90 per cent of the mass, are completely covered with an overcoat of alumina or clay, and the more uniform the grains are in size and shape the better is the sand with respect to porosity in relation to the average size of the grains.

13 It was found on passing a sample of sand a number of times through a hand riddle and making test bars from the sample after each riddling that the overhang was increased measurably. Thus, a sample of sand which, after tempering and mixing by hand with a spade, showed an overhang of less than two inches of the test bar, increased to nearly three inches after a dozen riddlings.

14 It would not be practicable to treat large masses of sand in this manner, even though a positive and valuable gain in the quality of the sand should be demonstrated by making test molds from patterns having considerable overhang in places, or in making fine toothed gear wheels, etc., nevertheless the information thus obtained was quite valuable and led to important practical results, as will be seen presently.

15 Another novel observation was concurrently made, *viz.* that the increase in toughness and porosity noticed in these tests might be partly due to "aeration", or to the separation of the grains of sand when falling from the sieve to the floor. In order to discover the truth or falsity of this view, a quantity of the sand was shaken in a box with a closed lid for several minutes, and test bars were made before and after shaking, the correctness of this theory was quickly shown, for the shaking without sieving proved to be more effective than the sieving without shaking.

16 Tests for porosity alone were also made, but as these were not very satisfactory, owing possibly to want of suitable means of accurately controlling and measuring the amount of air drawn through a mass of sand compressed in a tube, these tests were not prosecuted to a conclusion.

17 About this time William Sellers & Co., Inc., began to experiment with a centrifugal machine for mixing sand, and it was found that the desired result could be obtained with such a machine much more expeditiously and economically than by any treatment with riddles or chasers in a rolling mill, and at the same time, the toughness and the porosity were increased to a very much greater degree than was possible by the old methods. These satisfactory results led to further experiments in this direction that culminated in the development of a thoroughly practical centrifugal machine, simple in design and substantial in character, which proved so valuable in the foundry that it was placed on the market, and a large number are now in regular use in some of the largest establishments in the country as well as in many smaller foundries.

18 The machine is truly remarkable both as a labor saver and as an improver of molding sand. It accomplishes as much work by the help of two laborers in preparing molding sand as five men could do in ten hours by the old method. Before proceeding to describe the machine itself, attention is called to the half tone illustrations Figs. 1 and 2 showing tests made with facing sand for large and medium work before and after treatment by this new process.

19 There are three grades of molding sand in addition to core sand regularly prepared and used in the Sellers foundry for the different classes of work. They are classified under the names "Strong Sand," "Special Strong Sand" and "Fine Sand".

20 The Strong Sand is used for the majority of the large molds, such as planer beds and uprights, etc., and for the principal parts of other large machine tools. Most of these molds are skin dried, or baked on the surface, *in situ* by means of a portable drying oven after having been "wet-blacked".

21 The Special Strong Sand is used only for molds for the heaviest castings, such as large anvil blocks, etc., these molds are also wet-blacked and when baked on the floor are almost as hard as a stone or as hard as a baked loam mold; this mixture is all new sand.

22 The Fine Sand is used for all light castings and much of the "medium" work; these molds are not baked and constitute what are commonly called "Green Sand Molds".

23 It may be interesting to know the formulæ for the preparation of the three grades of molding sand given below:

STRONG SAND

Strong Lumberton sand	(new)	= 14 parts
Gravel	(new)	= 7 parts
Floor sand	(old)	= 6 parts
Coal dust		= 2 parts

SPECIAL STRONG SAND

Strong Lumberton sand	(new)	= 9	parts
Gravel	(new)	= 14	parts
Coal dust	(new)	= 2	parts

FINE SAND

Weak Lumberton sand	(new)	= 14	parts
Fine floor sand	(old)	= 4	parts
Coal dust		= 2	parts

24 Fig. 1 is from a photograph showing eleven bars, (6 by 1 by 1 inches) made from Strong Sand under uniform conditions of quantity, temper (dampness) and pressure of sand. The bar labeled *0* was pressed from a sample of the sand after having been dampened and turned over several times with a spade and only partially mixed;

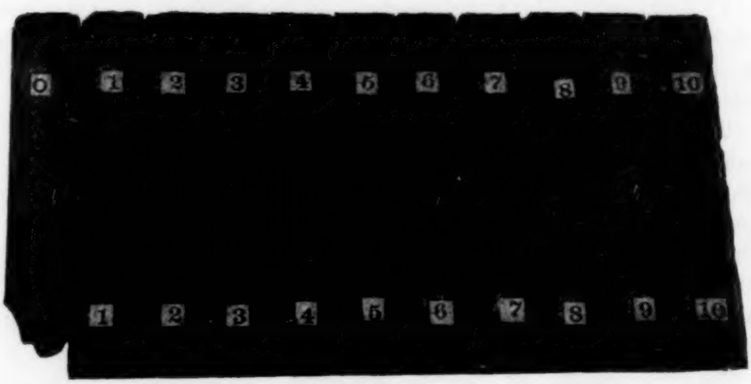

FIG. 1 GREEN SAND TEST BARS MADE FROM ONE SAMPLE OF SAND

the object of such preliminary mixing is simply to prevent the coal dust from flying out of the centrifugal machine on subsequent treatment. The other bars were made from the same pile of Strong Sand after passing through the centrifugal sand mixing machine from one to ten times. These bars were all laid side by side upon the smooth metal plate (about $\frac{1}{4}$ inch thick) resting upon a table, and they were slowly pushed over the edge of the plate until they broke.

25 The following table gives the measurements of the overhang of each bar as nearly as the somewhat irregular shape of the break permitted.

No. 0 Length of overhang = $2\frac{1}{4}$ inches
No. 1 Length of overhang = 3 inches
No. 2 Length of overhang = $3\frac{1}{4}$ inches
No. 3 Length of overhang = $3\frac{3}{8}$ inches

No. 4 Length of overhang = $3\frac{1}{2}$ inches
No. 5 Length of overhang = $3\frac{1}{2}$ inches
No. 6 Length of overhang = $3\frac{1}{2}$ inches
No. 7 Length of overhang = $3\frac{5}{8}$ inches
No. 8 Length of overhang = $3\frac{5}{8}$ inches
No. 9 Length of overhang = $3\frac{3}{4}$ inches
No. 10 Length of overhang = $3\frac{3}{4}$ inches

26 It will be observed that the first treatment increased the overhang three quarters of an inch, the subsequent treatments increased the overhang in some cases one quarter of an inch, and in some cases not measurably. The first treatment was therefore, the most effective, and for practical purposes, one treatment is often sufficient to insure good mixing of the materials and thorough disintegration of any lumps.

27 It may be stated *en passant* that the machine is not designed to remove nails, jaggers, or stones. If the sand contains such things it should be put once through a very coarse screen to remove them before passing into the centrifugal machine.

28 The strain tending to break the sand beam is increased by the additional weight of the increasing length of the overhanging portion and also by the increased moment of its center of gravity; it is readily seen, therefore, that an increase in length of the overhang of three quarters of an inch on the first treatment in the centrifugal machine means an increased tenacity of 75 per cent; in like manner an increase in overhang of 50 per cent means an increase in strength of sand of 225 per cent.

29 The illustration Fig. 2 shows the fractured surfaces of the same bars.

30 Bar No. 0 shows the heterogeneous components of the partly mixed sand, while the other fractures show increasing uniformity due to more thorough mixing and disintegration of lumps of gravel, up to No. 3, after which no further increase in uniformity is observable to the eye.

31 The illustrations convey a very fair impression of the actual appearance of the bars. The appearance of the fractured surfaces coincides with the tests for overhang and shows that a single treatment in this machine is, in many cases, sufficient, and two treatments are all that are usually needed with any sand mixtures.

32 In mixing core sand containing flour, the effectiveness of this centrifugal method is still more strikingly evident owing to the almost total disappearance of the white flour due to its thorough commingling with the sand and black coal in one treatment.

33 The tests here shown are typical of many others of similar nature that have been made, but to give a detailed statement of these would extend this paper beyond the desired limits.

34 In recent years there has been a remarkable reduction effected in the cost, skill required, and time consumed in making cores by the

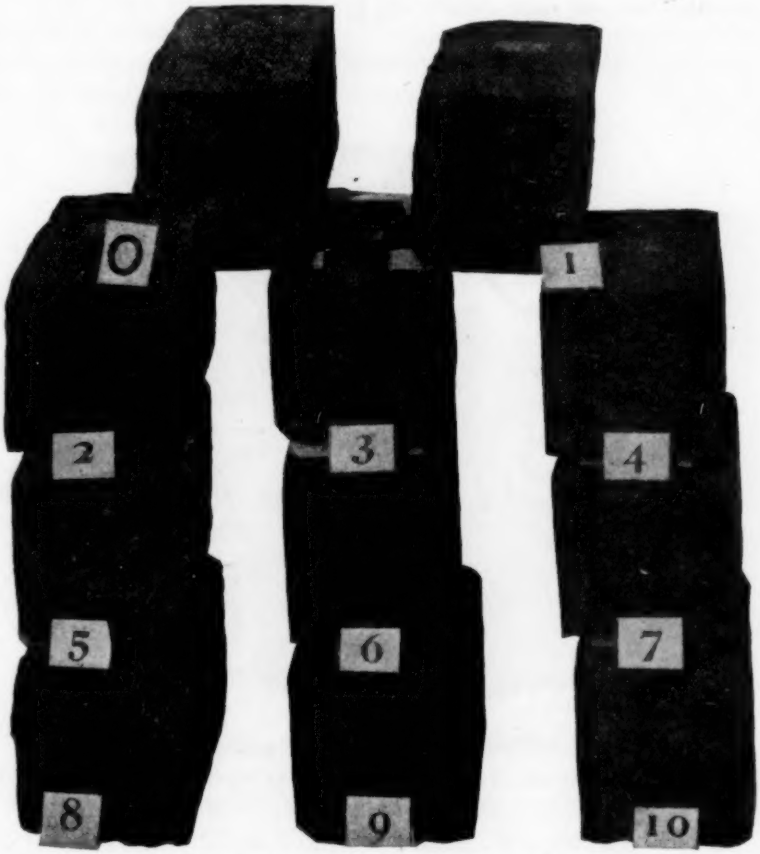

FIG. 2 FRACTURED SURFACES OF GREEN SAND TEST BARS

use of sharp sand and oil in place of the usual core sand mixed with flour or other binders.

35 The oil sand cores require no ramming and are made by unskilled labor; cases almost without number might be cited where the actual cost of cores has been reduced by the oil sand method from 50 to 75 per cent and over, and better results obtained in the

foundry, with fewer wasters caused by the breaking down or "blowing" of cores; no venting and but few core rods are needed. Thorough mixing of the linseed oil with the sharp sand is absolutely necessary, though rather difficult to obtain and in accomplishing this the centrifugal machine is preëminent; in fact, it would be impossible without this machine to produce the remarkable results that are now daily recorded with oil sand cores in the foundry.

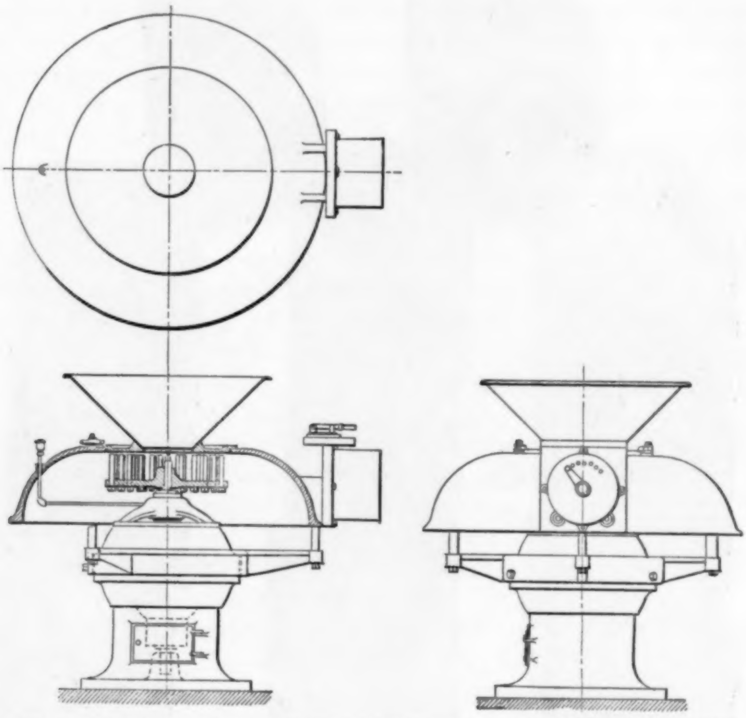

FIG. 3 SECTIONAL DRAWING OF CENTRIFUGAL SAND MIXING MACHINE MOTOR DRIVE

36 The centrifugal machine is, of course, equally well adapted to the thorough mixing of core sand with the various core oils and core compounds that are sold for making cores.

37 Experience has shown that in mixing sharp sand with oil for cores, the centrifugal machine should be run at a lower rate of speed than when mixing and at the same time tempering ordinary molding sand. Two treatments are sufficient to insure thorough mixing of sharp sand and oil for oil cores.

38 In conclusion, it will suffice to give a very brief description of

the Sellers' Centrifugal Sand Mixing Machine, two types being shown, together with a sectional drawing.

39 The Centrifugal Sand Mixing Machine consists of a rapidly revolving table, having on its upper surface a number of prongs arranged concentrically. The sand is fed into the hopper at the top of the machine, from which it falls upon the revolving table and is thrown by centrifugal force from prong to prong and out against the inside of the cover or hood. It emerges from beneath the hood in a fine shower, free from lumps and thoroughly mixed.

FIG. 4 CENTRIFUGAL SAND MIXER, BELT DRIVEN

40 The table, spindle, spindle pulley, and bearings are enclosed in the housing or base upon which the machine stands, so as to protect effectually these parts from sand and dust.

41 A removable door is placed at the front of the housing to afford access to the spindle and bearings for cleaning or lubrication. The hopper can be lifted off for convenience of cleaning the prongs or removing stones, nails, etc., which do not pass between them.

42 The high rate of speed at which the table revolves, from 800 to 1200 revolutions per minute, causes the sand to be tossed with much force from prong to prong, thus breaking up agglomerated lumps of gravel or clay, insuring not only complete disintegration

but a degree of mixing not attainable by any other method. Every portion of sand is thoroughly "combed out," and analytical tests have shown the uniformity of mixture of heterogeneous compounds after passing twice through this little machine.

FIG. 5 CENTRIFUGAL SAND MIXER, DRIVEN BY ENCLOSED ELECTRIC MOTOR

43 Fig. 4 shows a machine arranged to be driven by belt over the carrier pulleys at the back of the housing to the pulley on the table spindle.

44 Fig. 5 shows a machine driven by an electric motor enclosed within the housing where it is thoroughly protected from sand, dirt, etc.

CYLINDER PORT VELOCITIES

JACOB H. WALLACE, BOULDER, COLORADO
Non-Member

In this article the author wishes to present a method for determining the velocity of flow through the ports of a steam engine. No consideration will be given for the specific volumes at different pressures, but the flow will be considered at constant volume. The engine will be considered as having a constant rotative speed. The angularity of the connecting rod will be allowed for. While the method lends itself to the application of the Bilgram valve diagram, the error due to the angularity of the eccentric rod is not involved except in the diagram. A correction may be applied to the diagram in the usual manner. The essential principles involved include those of flow of fluids, displacement of valve, and velocity of piston movement. These and their application will be given in due course of presentation.

2 The principle of flow in its application to the port and cylinder of a steam engine may be stated thus: The volume which passes through the port is equal to the volume provided by the piston. The volume provided by the piston for any instant of time depends upon the area of the piston face and the velocity of piston movement. The volume which passes through the port depends upon the area of the port and the velocity of flow. Referring to Fig. 1, let A represent the area of the piston face, V the velocity of piston movement, a the area of the port, v the velocity of flow through the port. Then

$$AV = av \qquad [1]$$

To be presented at the New York Meeting (December 1907) of The American Society of Mechanical Engineers, and to form part of Volume 29 of the Transactions.

3 Let p represent the port opening and l the length of port measured across the cylinder. Then

$$AV = plv \qquad [2]$$

4 The Bilgram valve diagram will be used to represent the displacement of the valve. In Fig. 2, let S be the center of the engine shaft, YY_1 the line of stroke and direction of valve movement, E the position of the eccentric when the crank is on head end dead point Y. ES is the eccentric radius. Draw MS perpendicular to YY_1 and from E to MS draw QE parallel to YY_1. If the eccentric coincided with MS the valve would be in mid position. With the eccentric at E, the displacement of the valve to the right of mid position is represented by QE. Let e represent the eccentric radius SE and d the angle ESM. Then by trigonometry

$$QE = e \sin d \qquad [3]$$

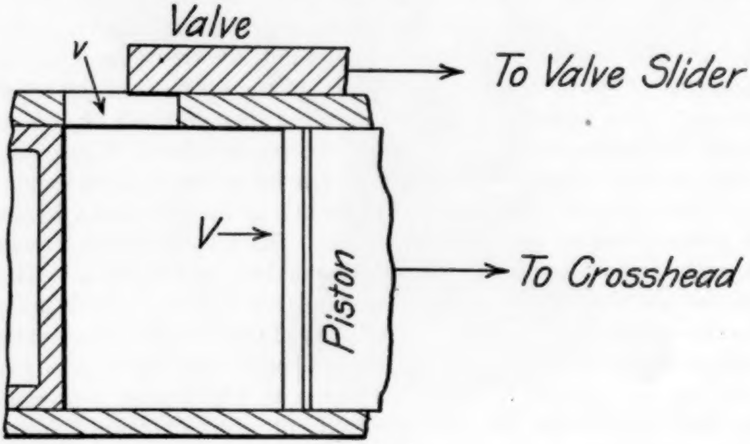

FIG. 1

5 Lay off counter-clockwise from SY_1 an angle Y_1SB equal to d, and SB equal to SE. Let R be the foot of a perpendicular falling from B to SY_1. Then the triangles RSB and QSE are equal, and BR is equal to QE. Whence

$$BR = QE = e \sin d \qquad [4]$$

6 Let the crank and eccentric rotate clockwise through an angle represented by b. The lines YY_1 and MS, and the point B remain stationary. With these conditions the movement of the valve is represented by Q_1E_1. By trigonometry

$$Q_1E_1 = e \sin (d + b) \qquad [5]$$

7 The perpendicular BR_1 dropped from B to the crank line C_1S produced, is represented by BR_1. By trigonometry

$$BR_1 = e \sin (d + b) \qquad [6]$$

Whence from (5) and (6),

$$BR_1 = Q_1E_1 = e \sin (d + b) \qquad [7]$$

8 Consequently B, chosen arbitrarily and fixed with reference to the shaft, direction of stroke and valve travel, may be taken as a point, and perpendiculars drawn to the respective crank positions

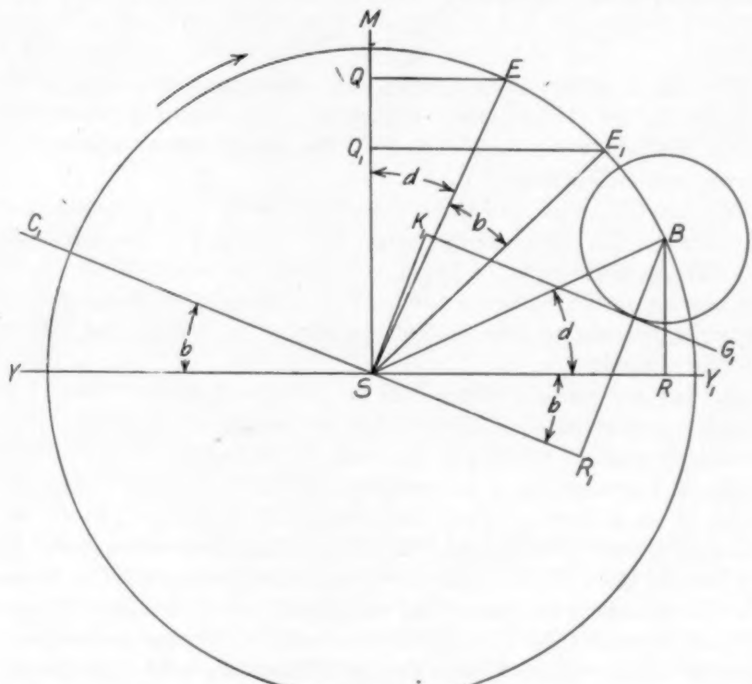

FIG. 2

and the length of the perpendiculars represent valve travel in each case.

9 The valve travel less the steam lap is equal to the port opening. Since the steam lap is an unchangeable quantity, describe a circle with B as a center and the steam lap as a radius. Then the perpendicular distance from the crank (produced if necessary) to the steam lap circle represents the port opening. Thus a line K_1G_1 drawn parallel to the crank and distant from it equal to the port opening is tan-

gent to the steam lap circle. This fact is utilized later in the presentation.

10 The velocity V of the piston movement depends upon T the tangential velocity of the crank pin C, the position of the crank in a revolution, and upon the ratio of crank and connecting rod lengths. The value of T depends upon the rotative speed and length of crank. All these items, except position of the crank in a revolution, are virtually fixed in any particular engine. Let r represent the length of crank, n the number of revolutions per minute and T the tangential velocity of crank pin center. Then

$$T = 2\,\pi r n \tag{8}$$

11 Fig. 3 illustrates a method for determining the value of V graphically. S is the center of the shaft, CS any position of the crank, WC the connecting rod, YY_1 the line of stroke, and MS is drawn perpendicular to YY_1.

12 Let CN, drawn to some convenient scale and perpendicular to the crank CS, represent the tangential velocity T of the crank pin C. CN also represents the actual velocity of the center of the crank pin bearing on the connecting rod. The velocity of W, the center of the wrist bearing, as also that of the piston has a direction WS in the line of stroke.

13 Let the motion of the rod be considered alone. Then are known the magnitude and direction of the velocity of the point C and the direction of the velocity of the point W. Consider the motion for the instant as made up of a translation parallel to WS and a rotation about W as a center. Then the velocity T represented by CN is made up of two components, one DN having a direction parallel to WS and the other CD having a direction perpendicular to WC. Then CD will represent the tangential velocity of rotation about W and DN will represent the velocity of translation. All points of the rod have the same velocity of translation. Hence the velocity of translation of W is represented by DN. But the velocity of translation is the actual velocity of W and also the piston. Hence DN represents the velocity V of the piston.

14 Now produce WC to L on MS. In the triangles CND and CSL the sides are perpendicular each to each. Therefore the triangles are similar and the homologous sides represent the same values. The length of the crank represents in magnitude the tangential velocity T. The length LS represents in magnitude the velocity V. By a similar construction the value of V may be obtained for any position of the crank.

15 With the principles available thus far presented, let a valve gear be assumed which will provide port openings so as to maintain a constant velocity through the port. In any assumed engine the size of cylinder and length of port across the cylinder are fixed. Consequently in equation (2) $AV = plv$, A and l are constant, and if v is also made constant the value of p depends upon the value of V. Furthermore a line which represents the value of V must represent the value of p. The scales however may not be the same. With v assumed constant, LS in Fig. 3 represents p to some scale.

16 In Fig. 4, K_2G_2 is a representative line of a series of lines drawn parallel to the representative crank position C_2S so that the perpendicular distance between K_2G_2 and C_2S is equal to L_2S. (This application has been anticipated.) A curve drawn tangent to the series of curves of which K_2G_2 is representative for the first quarter revolution will be tangent to YY_1 at right infinity and tangent to FH (KG

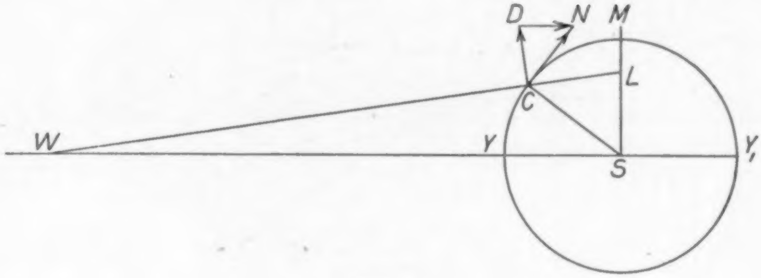

FIG. 3

for crank position MS) at upper infinity. It may be observed in the series of curves shown in Fig. 5 that the points of tangency appear within the limits of the drawing. This is as accurate as can be obtained on the drawing board. The form of the curve seems to have this feature. Furthermore that portion of the curve not shown is of little value.

17 Referring to Fig. 4, the curve for the second quarter revolution is tangent to FH at upper infinity and tangent to YY_1 at S. The curves for the third and fourth quarter revolutions are directly below and symmetrical with the curves of the second and first, respectively.

18 The assumed valve gear to provide a port p for a constant value of v must have a steam lap which can be represented in the Bilgram diagram by the curves for a complete revolution. In the usual engine designs, however, the steam lap is represented by a

circle. If for some crank position, KG is tangent to the circle and to the curve at the same time the same velocity of steam obtains for the two designs.

19 From equation (2) $AV = plv$, it is evident that for the crank in a definite position—V fixed—a variation of the value of v must be accompanied by an inverse variation of the value of p. This fact furnishes a convenient method for establishing curves for other values of v.

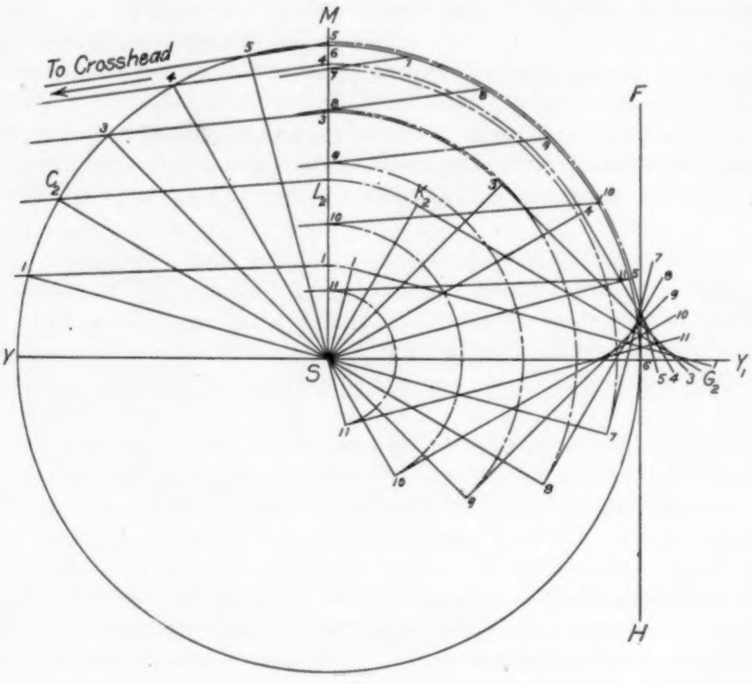

FIG. 4

20 It is fortunate that the form of the curves does not vary for a given ratio of crank to connecting rod, and a scale of velocities can be readily applied to a series of curves, no matter what size the engine may be. The set of curves shown in Fig. 5 is adapted to all engines which have the ratio of crank to connecting rod 1 to 6.

21 In order to illustrate the application of the set of curves just established, let the proportions and speed of a certain engine be assumed as follows: the diameter of cylinder, 6 inches; crank length, 5 inches; revolutions per minute, 200; length of port across cylinder, 4 inches; length of connecting rod, 30 inches. Let B, Fig. 5, be the

center of the head end steam lap circle of the Bilgram valve diagram, and C_2S any position of the crank. Draw a line tangent to the lap circle parallel to the crank and ascertain to which curve of the same quarter revolution the line is tangent. Interpolate if necessary. The line will be tangent to only one curve for the same quarter revolution. Now follow the curve upward to O.

22 The scale for determining the value of v corresponding to the position of O is obtained as follows: If the position of the crank were coincident with MS, the value of V and T would be equal. Let this

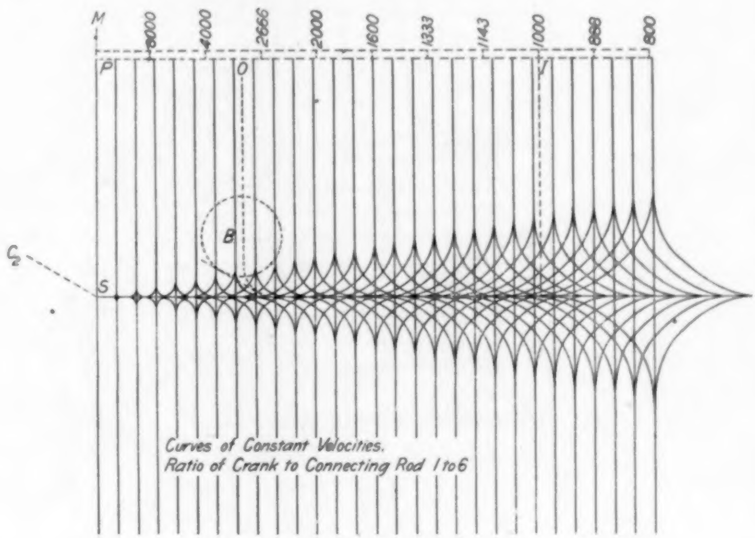

FIG. 5

condition be assumed. Also let the value of v be 1000 feet per minute. Then substitute in (2) $AV = plv$ and solve for p.

$$A = \frac{3.1416 \times 36}{4} \text{ sq. in}$$

$$V = T = 2 \times 3.1416 \times \frac{5}{12} \times 200 \text{ feet per minute.}$$

$$v = 1000 \text{ feet per minute.}$$
$$p \text{ (calculated)} = 3.7 \text{ inches.}$$

23 Since this value of p is for the crank coincident with MS, locate a point 3.7 inches to the right from S. Through this point draw a line parallel to MS so as to intersect at I a line PO drawn

parallel to YY_1. Upon PO construct a scale with the position I for the value of $v = 1000$. A point midway between I and P corresponds to a value of $v = 2000$. Other graduations may be located similarly. By estimation it may be seen that the value of v corresponding to O is about 3000. With the distance PO as a unit, measure away from MS to a numbered division coincident with a full measure as 3 units to 1000. Now 3×1000 is the desired value of v.

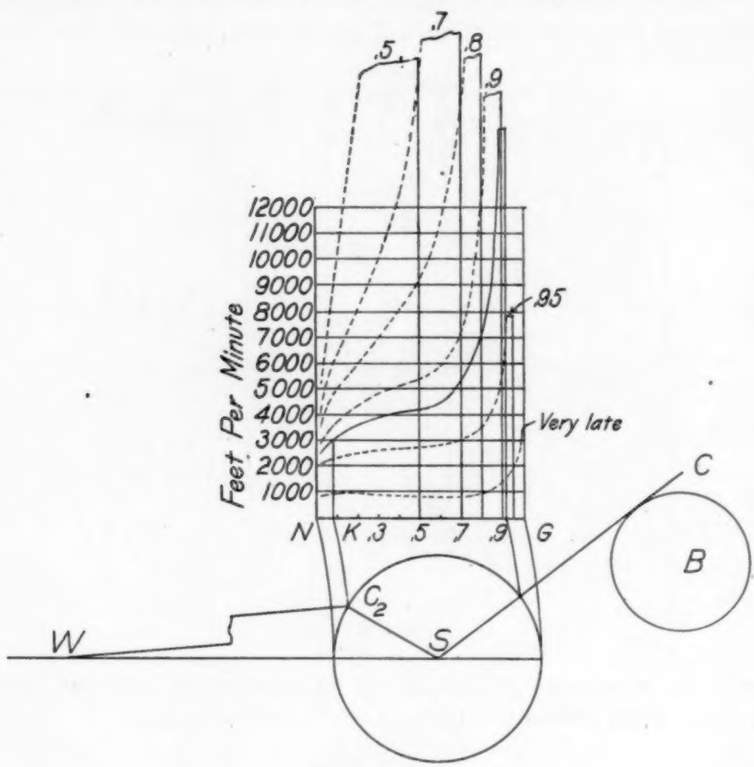

FIG. 6

24 By assuming some scale for the crank and connecting rod, not necessarily the same as that for the eccentric and Bilgram diagram, the position of the piston in its stroke corresponding to the velocity just found, may be determined. This is illustrated in Fig. 6. S is the shaft center, C_2 the crank pin center and W the wrist pin center. Draw NG parallel to WS so that an arc drawn with W as center and C_2W as radius will intersect NG at K. The total stroke NG may be found from dead point positions of the crank by similar

constructions. Now erect, to some convenient scale, an ordinate from K to represent 3000 feet per minute. By obtaining the steam velocities for other positions of the crank other points may be located

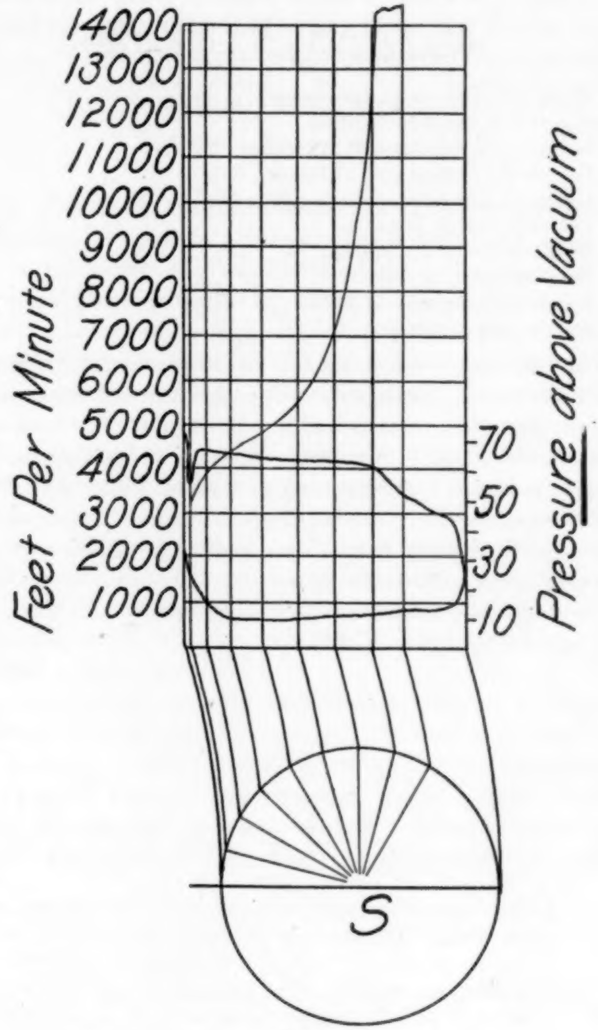

FIG. 7

and a curve, shown by solid line drawn connecting them. The ordinates of this curve represent steam velocities for positions in the stroke corresponding to their positions on NG. The curves

shown by dotted lines were obtained by changing the point of cut off and maintaining a constant lead. Such a set of curves would correspond closely to those for certain designs of shaft governors.

25 In Fig. 7 is shown a steam velocity curve and an indicator card for a certain test on an engine in the laboratory of the University of Colorado. The data of the test are as follows:

Maker of engine, B. F. Sturtevant.
Size of cylinder, 6 by 9 inches.
Length of connecting rod, $27\frac{1}{2}$ inches.
Length of eccentric rod, 21 inches.
Length of port across cylinder, $4\frac{3}{8}$ inches.
Eccentric radius, $1\frac{1}{4}$ inches.
Head end steam lap, $\frac{15}{32}$ inch.
Head end lead, $\frac{1}{32}$ inch.
Revolutions per minute, 207.
Scale of indicator spring, 40.

26 The position of the crank for cut off (corrected for angularity of eccentric rod) was 120 degrees. The apparent cut off, as suggested on the indicator card, corresponds to a position of the crank at about 108 degrees, and to a steam velocity of about 14 000 feet per minute. The drop in pressure, corresponding to a steam velocity of 7000 feet per minute, is about five pounds per square inch. This however may not all be due to velocity through the port. A variation of pressure in the valve chest may have occurred. This point and others are left for further investigation.

HIGH SPEED ELEVATORS

By CHARLES R. PRATT, NEW YORK

Member of the Society

The type of elevator selected for the new Singer building and for the tower of the Metropolitan Life Insurance building is known as the Gearless 1 to 1 Traction Electric Elevator, the driving mechanism for which is a motor located over the hoistway, with a traction sheave and a brake pulley on its armature shaft. The ropes from the car pass over this traction sheave, down under an idler sheave, and again over the traction sheave and down to the counter-balance, giving two half traction turns over the traction sheave to drive the difference in weight between the car and the counter-balance. This traction has been found to be sufficient in ordinary passenger elevator service, especially in high rise elevators on account of the weight of the ropes and variable counter-balance chains or ropes, the latter leading from the bottom of the car to the bottom of the counter-balance, thus adding to the *constant* load on the ropes leading to each face of the traction sheave, thereby reducing the *variable difference* in traction load caused by the variable passenger load.

2 The diameter of these traction sheaves is about 40 inches, the least permissible for proper wear of ropes, which gives a circumference of 125.6 inches or about 10½ feet, which at 600 feet per minute car speed requires 57 r.p.m. of the hoisting motor. 2000 pounds net load at 600 feet per minute would require a motor of about 50 h.p. which at 57 r.p.m. would be a motor of about 200 h.p. size, cost,

To be presented at the regular Monthly Meeting Tuesday evening, November 12, 1907, of The American Society of Mechanical Engineers, and to form part of Volume 29 of the Transactions.

weight, etc. The loss of motor efficiency at this low speed is compensated for by the saving in friction loss due to the elimination of all transmission gearing between the motor and the ropes.

3 The brake pulley being the same or but little larger diameter than the traction sheave, requires a frictional resistance of the brake shoes equal to the net load, or the same that is required by a safety device on the car to stop the car by gripping the steel guide rails; the usual reduction in speed is made by the dynamic action of the motor nearly to a stop; the brake however must have power enough to do this alone if required.

4 This elevator is a product of elimination, discarding all unnecessary frictional parts, and having the least possible mass moving at high speed, it eliminates:

- *a* Friction of worm, spur, screw, or rope and sheave gearing,
- *b* Excessive size of winding drums.
- *c* Dependence upon automatic limit stops.
- *d* Inertia of moving mass of metal and water in hydraulic elevators.

5 Experiments made by the author on this form of traction rope drive, using iron wire hoisting ropes running in smooth round grooves in the traction sheave, with from $1\frac{1}{2}$ to $7\frac{1}{2}$ half traction turns, demonstrate that the least traction obtained is with new dry ropes on new dry grooves, and that after considerable running there is not 5 per cent difference in traction between a dry rope and a rope flooded with any kind of lubrication. This establishes the fact that if this elevator will handle its full load when it is first started with new ropes, it will always handle its full load safely.

6 The two distinct advantages that this elevator has over all others is unlimited rise and safe normal limit stops. Its unlimited rise is obvious. Its safe normal limit stops are due to landing of the car or counter-balancing on buffers so constructed that they will stop the car at full speed without injury or discomfort; and when either car or counter-balance so lands at the bottom of the hoistway, the tension of its ropes leading to the traction sheave is so reduced that all traction is lost, and motor and sheave can keep on revolving with no further travel of car or counter-balance. Hoistway limits are of course used to reduce the speed and stop the car at the terminals, but these very effective buffers are set to work at top and bottom floors. They are therefore used every round trip and are thereby kept in working condition, which would be a good safe guard against loss of control in any elevator.

7 Installations of differential and of constant tension traction

rope drive have been made, but this simple direct method is now the only one considered, and was advised by the author in his paper on "Elevators" in Transactions Vol. 20 (1899), page 826.

8 The new Singer building and the tower of the Metropolitan Life Insurance building call for a speed of 600 feet per minute at rises of 500 feet and over. Hydraulic elevators of the plunger and of the inverted plunger type were offered for this service, and their claims were very thoroughly considered, but the adaptability of this Gearless 1 to 1 Traction Electric Elevator for these high rises, and its success in several other installations, decided without question in its favor.

9 Of the tower of the Metropolitan Life Insurance building, the writer can speak from personal knowledge, as he represented one of the bidders. The selection of elevators for that building was referred to a most distinguished board of engineers; Messrs. Mailloux, Knox, Professor Spangler and J. C. Knight and C. L. Duenkle, who were retained by the Metropolitan Life Insurance Company during April, May, June and July, in which time they took over 1500 pages of testimony, and personally inspected everything that was proposed for the plant. In regard to this for the first time in the writer's elevator experience, the safety device on the car was given due prominence. Reference is here made to the author's paper on "Elevator Safeties," Transactions Vol. 23 (1902), page 536.

10 Although this Gearless 1 to 1 Traction Electric Elevator has been used in high class passenger elevator service but a few years, its universal success proves in practice all that its merits indicated in theory. The writer knows of no troubles in its operation, or of accidents to suggest danger; and yet there has been the most important element of safety omitted, *viz*: *positive speed control and holding power*. This however can be easily restored without extra cost or other detriment to its merits by replacing the friction brake by an independently driven *low* pitch worm gear.

11 It is well known that worms of less than 5 degrees angle can not be driven by their worm gears, also that they are inefficient, and it would not be practicable to drive an elevator at 600 feet per minute with one. Such service would require an angle of worm of about 20 degrees, which would allow the gear to drive the worm easily, and the car to travel at a dangerous speed if unchecked by motor or brake, and this is what usually occurs when the newspapers report that "the car fell — stories." Efficient motor speeds also require low angle of worms for slow speed elevators, and steep angle of worms for high speed elevators.

12 Electric circuits controlling motor and brake are liable to fail on any electric elevator, but the hoisting apparatus should be so constructed as to prevent *positively* any excess of normal speed and bring the car to a safe stop should this occur.

13 It is well known that two electric motors can operate without interference when positively geared together. Frank J. Sprague had two electric motors positively geared to the same drum shaft on his Central London Railway Elevators.

14 All high speed hoisting mechanism can be easily driven by the action of gravity, but if a low pitch worm gear positively geared to that mechanism be independently driven so as to synchronize with its normal motion, a positive speed regulation is established, which not only prevents excess of speed, but assures perfect acceleration, dead lock at stop position, and will come to stop normally upon failure of current.

15 A friction brake on a high speed electric elevator interferes with its operation, lessens its efficiency, and has no positive function of safety. To replace it with a worm gear control on a Gearless 1 to 1 Traction Electric Elevator is a simple matter, *viz:*

- *a* Replace the brake pulley with a worm gear having its worm driven by an electric motor, called the Controlling motor.
- *b* Have the worm gear ratio such as to obtain the greatest efficiency in the Controlling motor at the greatest range of speed by its field regulation.
- *c* Construct a worm that can not be driven by its worm gear, without reference to how great its lead may be, by making its diameter large enough to keep its angle of thread below 5 degrees, and by large diameter thrust washers. This worm gear has little work to do at high speed and will run cool.
- *d* Connect up the Controlling motor in circuit with the Hoisting motor so they will synchronize with each other in starting, stopping and speed regulation.
- *e* With both motors open circuited, the car gradually and *positively* stops, because it can not drive this worm gear.
- *f* With the Hoisting motor open circuited:
  1. Driving against gravity with a heavy load, the Controlling motor blows its fuse and stops.
  2. Driving in the direction of gravity, or with a light load *against* gravity, the Controlling motor drives the traction sheave under the control of the operator in the car, and brings the car to its floor.

g With the Controlling motor open circuited, the Hoisting motor fuse blows, and the car gradually and positively stops, as in case *e*.

h The Controlling motor governs acceleration by its field regulation, and the Hoisting motor requires no finely graduated starting resistance, which simplifies the control.

i The Controlling motor governs speed when driving with gravity, and the Hoisting motor requires no armature shunt, this saves direct loss of power.

j The foregoing refers to these two motors being connected up in parallel, the same or possibly better, results may be obtained if they are connected in series, with slightly different action. Either way is standard practice.

16 No experiment is here involved; it is merely a practical combination of standard elevator construction; but in this combination is a new principle of elevator control more perfect and safe than the best hydraulic.

17 "A chain is only as strong as its weakest link." In a Gearless 1 to 1 Traction Electric Elevator we observe a multiplicity of wire ropes, heavy sheaves and shafts driven by a motor of ample power and held by a friction brake, and then close our eyes to the fact that this motor and brake are alternately deprived of their motive and holding power every few seconds. Should one happen to let go before the other takes hold, the car *falls free* to the bottom of the hoistway, unless stopped by some device in the hoistway. No amount of ingenious electric circuits established for coöperative action between an electric motor and a friction brake, can make either of them a *positive means* to hold an elevator car, or keep it from attaining a dangerous speed. Neither of them at their maximum have a holding power of over twice the load. No factor of safety of 10 exists here. A low pitch worm gear can not drive its worm, nor can a hydraulic valve be placed in a position where the car can travel at a dangerous speed; and when these normal positive elements of safety are omitted from a high speed elevator, disaster is sure to follow sooner or later.

18 Two forces act on the armature of an electric elevator motor, *i.e.*, gravitation *versus* electro-motive force, and between these forces, either incidental to transmission of motion, or for the purpose of stopping and holding the car, are interposed elements of friction, such as worm gears and friction brakes.

19 Under normal conditions the electric motor can start, stop and control the speed of the car, only requiring a friction brake to hold it at rest, or to check it at reduced speed. But such a brake, particu-

larly on a gearless elevator, is a very large and costly affair, requiring very delicate adjustment, and can not be considered to be a positive protection against excess of speed.

20 *Suppose that in place of the brake pulley on the armature shaft, there was placed a worm gear,* with teeth as strong as the brake's friction, *and of such low angle of thread that the force of gravity could not cause it to revolve its worm*; and that to its worm was attached a small high speed electric motor, so connected to the circuit of the main motor as to cause them to synchronize with each other. The action would be:

- *a* Both motors would start together to move the car. *No brake to be released.*
- *b* The main motor would relieve the small motor of all gravity load.
- *c* The small high speed motor, under no load, would have a perfect acceleration in starting and stopping, and by its worm gear would resist any imperfect acceleration of the main motor, thereby insuring a perfect motion in starting and stopping the car.
- *d* With proper angle of worm, and suitable thrust washers, this worm gear could not under any possible conditions be driven by the force of gravity, hence it would be impossible for the car to exceed its normal speed as long as the ropes hold it to the driving drum or sheave.
- *e* With the usual dynamic action, this motor and its worm gear will come to a perfect stop and hold the car positively without the aid of any brake on either motor.
- *f* With no brake circuits, and fewer contacts for starting current, the electric control becomes far more simple and reliable.

21. This device, in place of the friction brake, would add but little to the cost of the elevator, and would make a material reduction in kw-hr. per car mile, for two reasons, viz:

- *a* Saving in starting current, as described in paragraph 23.
- *b* To run at slow speed when the main motor is being driven by gravity, the controlling motor by its full field and worm gear maintains the slow speed using little or no current, and the main motor with only resistance to the line, *returns* current to the line, instead of *taking* current from the line to resist gravity, as is now done.

22 With this device attached to a Gearless 1 to 1 Traction Electric Elevator, the following conditions would be obtained:

a Positive limit stops.
b Absolute limit of speed.
c Perfect acceleration.
d Shortest possible distance in starting and stopping.
e Perfectly smooth motion.
f Dead lock at stop position. (Without using any brake.)
g Highest possible rise and speed.
h Least space occupied.
i Least cost of installation.
j Least cost of operation.
k *Perfect safety.*

23 Starting the car: In a gearless elevator, the car at rest is held by a friction brake, and before this brake can be released, the motor must exert a pull on the ropes equal to the maximum load, (of car or counter-balance); in practice the motor must exert a pull equal to this load plus a considerable more against the friction of the brake, or 25 to 50 per cent more than is necessary to start the load; which not only adds to the amount of electrical energy expended, but requires delicate adjustment to obtain a smooth start. *When the car is held at rest by the auxiliary worm gear device the hoisting motor has only the gravity load to overcome, simply like picking up a weight that lies on a floor,* thus saving starting current and obtaining a more perfect starting motion.

24 The positive locking and speed regulating functions of this worm gear device eliminates from the electric control all the complicated, costly and unreliable devices, which have compared so unfavorably with the more simple and positive action of hydraulic elevator valves, leaving only the few reliable switches to control the current direct to these two motors.

25 While the small angle of this worm prevents its being driven by its worm gear, it will still transmit 30 to 50 per cent of the power of the Controlling motor to drive the traction sheave and the car.

26 Elimination of gearing, compactness and simplicity in construction require the slow speed Hoisting motor. The high speed Controlling motor *and its worm gear,* with its greater field variation, greater inertia to maintain uniform acceleration and speed, greater *relative* starting power and torque at slow speed, *positive speed control and holding power, make any high speed electric elevator hoisting apparatus perfectly safe.*

INDUSTRIAL EDUCATION

The Apprentice System of the New York Central Lines

By W. B. RUSSELL
Junior Member of the Society

The necessity for an adequate recruiting system for the supply of trained mechanics is evident to all who are familiar with our present industrial conditions. The object of this paper is to present the details of a comprehensive, practical and workable apprentice system, which is already in successful operation, and which, because it is constructed upon carefully studied basic principles, can be made to work under all conditions and in any branch of manufacturing or repair work.

2 Efficient apprentice training is expected not alone to raise the grade of mechanics, and to provide from the ranks the necessary leaders and officers, but also to produce ultimately an organization in which men and officers alike can think intelligently, an organization replete with coöperation and efficiency; with its members bound together by association and by training, an organization fully equipped to meet the increased demands of progress and competition. Our large manufactories and railroads are suffering from a lack of knowledge of their men and the possibilities of these men. Large companies are too apt to go outside for their leading employees simply because they have no means of knowing whom they have in their midst capable of filling the important positions. It is not the

To be presented at the New York Meeting (December 1907) of The American Society of Mechanical Engineers, and to form part of Volume 29 of the Transactions.

mere training of workmen that is needed. We want also a system which automatically necessitates intimate knowledge of the capacity and possibilities of the material at hand. Nothing will reveal or cause ability and capacity to discover itself as will a well regulated apprentice system.

3 To train an apprentice and not to make use of him when out of his time is to lose the best results of the effort, and yet but few organizations at the present time are prepared to make intelligent use of graduate apprentices. The bright boy is blamed for leaving at or before the completion of his term, but the fault is largely due to the failure of his employer to appreciate his true value and to make further progress possible. It is not economy to spend three or four years perfecting a boy and then to let him go, and a continuance of such policy will ultimately kill the best apprentice system. Nothing less than a complete and radical change of policy is needed in most organizations to fit them both to attract and to hold apprentices.

4 The apprentice system as now organized on the New York Central Lines, was inaugurated on March 1, 1906, by Mr. J. F. Deems, General Superintendent of Motive Power, although evening schools for apprentices had existed for a number of years at several of the shops. The system here described has the hearty approval of both men and management. It is a cold-blooded business proposition, which has paid for itself from the start, and which has not a particle of philanthropy connected with it.

5 The general plan is two-fold and provides for shop instruction of the apprentice in the trade and for his instruction in educational subjects allied to his trade during working hours while under pay.

6 A shop instructor teaches the trade in the regular shop and on the regular work. As the majority of the apprentices at each shop are machinists, the shop instructor is preferably an up to date all around machinist giving instruction in the machinist trade, but with sufficient knowledge of the other trades, which may have apprentices, to be able to supervise intelligently apprentices in those trades. If the shop is small he gives only a portion of his time, while in a large shop his entire time is taken and he may require assistants. He must possess the necessary tact and be invested with sufficient authority to command the respect, coöperation, good will and confidence of all concerned.

7 The educational classes are taught by a second instructor who may be either a draftsman, an advanced mechanic, or a mechanical engineer. His previous education is of less importance than his

ability to explain simple shop problems, and his appointment should be based as much on the possibilities of his development as on his actual attainments. Previous experience in teaching is not necessary, although experience in teaching evening classes may prove helpful. The ideal instructor is a man who can look at problems from the stand point of the apprentice, who can work them out with the apprentice, and who can bring himself to realize and appreciate the difficulties as they present themselves. This type of instructor may often be the man who is obliged to study nights to keep ahead of his class. The educational instructor should spend only a part of his time in teaching, and will be able to keep the educational work closer to company practice and himself in line of promotion in the organization if he at the same time retains a position in the shop or in the drafting room. Where the educational work is sufficient to require the full time of one man, an assistant should be provided and both should give part time to the work.

8 The fact that the shops of the New York Central Lines are widely separated, necessitated the organization of a central department. Mr. C. W. Cross, who was well known throughout the New York Central system as the master mechanic of a large division, was appointed as superintendent of apprentices to have general supervision of the work. The educational features were delegated to the author. The central organization was also desirable to procure uniformity of effort and to prevent waste of time and energy on unprofitable experiments. The problem of making the men of the future is one of such magnitude, and the questions arising on a large railroad system are so numerous that it is necessary to have one or two persons who shall give their entire time to this work.

9 The plan is now in operation at the nine larger shops of the system and already includes about five hundred apprentices. A uniform set of regulations has been adopted showing the classes of work in the shop and the time allotted to each class. These regulations have been made sufficiently flexible to suit the various conditions in different shops, to insure the prompt movement of all apprentices and yet to allow more rapid movement where special merit warrants. Uniform apprentice certificates are issued at the completion of the regular course which entitle the holder to preference in employment at all shops of the system.

10 All of the work done by the apprentices is a part of the shop output. The shop instructor is present to make each machine run at its best efficiency, even when handled by a "green" apprentice. The apprentices are still responsible to the foreman as formerly, but the

foreman is relieved of the necessity of instructing them and is left free to run his department. The shop instructor passes on applicants for apprenticeship and in connection with the educational instructor recommends dismissal if unsatisfactory during the first six months. The shop instructor also arranges the changes of work in conference with the foreman. He keeps fully informed of the conditions existing in the various departments of the shop; he is in close touch with the foremen and gang bosses; he knows when and where the stress of work is heaviest, and in making suggestions and recommendations he takes these matters into account. His position in the shop is such that his judgment is accepted by the foreman, and his recommendations followed by the shop superintendent. His personality is such that he inspires the respect, and at the same time invites the confidences of the apprentice. From the nature of his work he is kept in touch with the latest shop practice and is in line of promotion in the shop organization.

11 Class room instruction is largely individual, as the same class may contain apprentices just starting and others nearly out of their time. Educational ideas have been reversed. Much that is dear to the mathematician and physicist has been discarded. The work is so arranged that each apprentice may go as rapidly or as slowly as his ability allows. All principles are handled through shop problems and must have practical bearing. Class work is closely adapted to shop conditions. The problems are worded in the language of the shop. The whole scheme of education is simple and more elementary than usual, although it is made to include many principles of mechanics, strength of materials and steam, usually taught in technical schools. In fact the course of study fits the conditions, and the conditions are not those imagined by most educators.

12 Text books cannot be used directly for apprentice instruction even if suitable books could be found, as the average apprentice has a strong aversion to books. The literature for such instruction is yet to be written. One or two books are now available for reference, but the bulk of this material must be in the form of separate sheets, given out one at a time and arranged to advance gradually.

13 The chief features of the educational work are mechanical drawing, which is made the back bone of the course, and shop problems which includes the other branches. The drawing is arranged to start directly on working drawings of actual machine and locomotive parts and yet to advance so gradually that even a dull boy can make headway. No time is taken for pure theory, and skill in drawing lines and making letters is obtained incidentally while making useful

drawings. Blue print sketches are used to assist the instructor, but these are drawn so that they cannot be copied and each sketch leaves more or less to be worked out by the apprentice.

14 Mathematical problems as met with in a shop, or for that matter in every day life, do not come classified with the rule at the top of the page. They are not even divided into arithmetic, algebra and geometry, and apprentices often meet problems so mixed in with facts, and so combined in the practical application of natural laws, that in many cases they do not appear to be mathematical problems at all. Shop problems taken indiscriminately from practice and put before apprentices would result in confusion and failure, but it is possible by a careful selection and adaptation to get together problems clothed in every day language, which are practical and useful and which, though actually classified and to some extent graded, do not show the classification. The terms algebra, arithmetic and mathematics are never used, and the sheets are not divided according to subjects. A running review is maintained by constantly introducing problems on the ground already covered.

15 Interest is further held by varying the standard of difficulty and mixing the easy and the hard problems as they are apt to come in practice. In getting together these problems, all departments of the railroads and many outside sources of information have been utilized. Company drawings, standards, and records, facts and data from the technical press, suggestions from motive power officers, problems directly from the shop and drafting room, hints from instructors and points picked up in conversation with foremen and mechanics have alike been used. Experimental apparatus is being installed in the school room so that natural laws may be illustrated, but not necessarily proved, as it is the intelligent use of these laws, and not their proof which is desired. Models and actual machines are used for illustrations. In gearing, the gears are fitted on to a screw cutting lathe in the school room and revolved as a check to the method of figuring them. Locomotive valve setting is introduced by a thorough course in valve setting on a stationary engine located in the school room and arranged to run by compressed air. Lectures are not well suited for apprentice instruction and when used must be short and must take the form of talks or recitations.

16 Classes are held from 7 to 9 o'clock in the morning; each apprentice reporting for two mornings a week. The apprentices ring in at the shop and then come to class rooms located on the shop property, where they are under shop discipline. At 9 o'clock they report again in the shop. Compulsory evening classes for appren-

tices have never been entirely satisfactory, but the plan of holding classes during working hours has been used by the British Admiralty for 60 years with entire success. Home work is expected on the problems.

17 An elaborate system of reports from both instructors is made to the local shop officers who forward them to the superintendent of apprentices. These reports show first, the ability at the trade, second, the disposition and personality of the apprentice, and third, the standing in class work. The instructors are at all times required to know the standing of each apprentice, thus making examinations unnecessary. Special emphasis is placed on the personal touch maintained between the instructor and the apprentice with a view to determining the type of work or branch of service for which the boy is best suited.

18 This movement differs from most efforts to better industrial conditions, in that it starts at the bottom in marked contrast with the common practice of providing special advantages for the especially bright. In this respect it is not unlike the type of training proposed by Mr. M. P. Higgins in a paper before this Society in 1899. The rank and file are not touched by special apprenticeship or special courses at high schools. Industrial education must start lower down the scale, and the genius will be the first to profit by the advantages offered. The problems designed for a boiler-maker apprentice have been found quite useful with college graduates and the problems used for apprentice classes have been used with equal success in evening classes for foremen, mechanics and inspectors.

19 Experience has proved the desirability of keeping boys in direct contact with the shops from the very outset, in which point the plan differs from that of Mr. M. W. Alexander of the General Electric Company as described in his paper of last year.

20 The immediate and direct results of the apprentice system have been, increased output, (notwithstanding the four hours per week spent in class) less spoiled work, ability to read drawings, to lay out templates and to make sketches, a better grade of apprentices, increased interest in the work, suggestions of apprentices as to improved methods and tools, draftsmen for company drafting rooms and apprentices fitted for special work as needed. Local officials have everywhere been quick to note the benefits of apprentice training, and are unanimously enthusiastic and interested. One immediate result of the opening of the apprentice schools was the request from foremen and mechanics for educational classes of a similar nature, which resulted in the organization of self supporting

evening classes at seven of the shops taught by the apprentice instructors, using practically the same courses of study as provided for apprentices.

21 The essential points in the inauguration of an apprentice plan like that described may be stated as follows:

a The full endorsement and the support of the management from the president down, and the hearty coöperation of all concerned. Without this the movement is sure to fail.

b The necessity of preparing a shop organization to make use of the apprentices who are thus trained, so that bright young men will be attracted to start on an apprenticeship which will graduate them into an organization where ability will be recognized, and where advancement will be possible.

c The selection of a shop instructor, possessed of the necessary skill and tact who shall give a portion or the whole of his time, according to the size of the shop.

d The selection of an educational instructor who shall have sufficient originality to cut away from current educational practice and to meet the local needs of the apprentice in his own way.

e The outlining of a course of study which will closely combine the theoretical and practical, and which will be framed for the dullest apprentice and not for the high school graduate.

f A recognition of the fact that the best results can be obtained only when the instruction is on the shop property and under shop control and that technical schools, trade schools, correspondence schools, high schools, Y. M. C. A., or other outside agencies, cannot satisfactorily meet the needs of the rank and file of apprentices.

g The use of a room for drawing and class work near the center of the shop property.

h A realization that the plan can be installed in most shops with talent already employed.

i A recognition of the fact that instruction must be given during shop hours and that evening classes for apprentices are unsatisfactory.

j Industrial organizations are composed of men, not machines, and in the long run, no organization or department can prove really efficient which does not make allowance for

the full development of its men and which does not count on the value of the personal touch in developing a proper loyalty and efficiency.

k The shop management must be prepared to provide evening classes self supporting, or nearly so, on account of the fees charged, for the present foremen and mechanics who are sure to ask for an opportunity to obtain educational training similar to that of the apprentices.

22 No previous reference has been made to the most important principle underlying apprentice training. In addition to teaching the apprentice a trade and teaching him to think, it is vitally necessary to aid in the development of his moral character and in his loyalty to the right. These objects do not, from their nature, permit of immediate demonstration of success. They are, however, vastly important and the character side of the problem is, in the long run, the larger side. It would require an entire paper for its full treatment. No apprentice plan can possibly succeed if this part of the problem is not uppermost in the minds of those in charge. Neither the employer nor the community has anything to fear from the right-minded, conscientious man who thinks. Much may be feared from one who is not conscientious and right-minded or one who permits others to do his thinking. The author believes that the value to the employer, the community and the country of the influence of intimate association between apprentice boys and big-minded, "broad gage" instructors cannot possibly be over estimated. In comparison with this influence mere details of the apprentice plan are absolutely insignificant.

POWER SERVICE IN THE FOUNDRY

By A. D. WILLIAMS, Jr., PITTSBURG, PA.
Non-Member

In view of the progress that has been made in other mechanical lines, it is remarkable that the foundry of to-day remains much as it was in the past. Since it plays a most important part in the industrial economy of all metal manufacturing plants, either directly or indirectly, it merits better treatment than it has received.

2 Some years ago the chemists turned their attention to the foundry and the results are seen in the replacement of empirical by scientific methods of mixing and melting and in the heat treatment of castings. The concrete results of their experiments are apparent in a reduction of the percentage of castings lost and the production of castings better suited to the purpose for which they were made.

3 The mechanical end of the foundry offers an interesting field for the engineer, not only in the designing of the castings, but in the invention of ways and means suited for their production. To a degree this work has been started, but has been confined to the production of molding machines and appliances, and the greatest progress has been made in those foundries which are devoted entirely to special lines of work, in which large quantities of castings of the same or similar characteristics are turned out. In the foundry whose output comprises a large variety of castings ranging from bench work to heavy housings and bed plates, the methods in use today differ but slightly from those of twenty years ago, the improved

To be presented at the New York Meeting (December 1907) of The American Society of Mechanical Engineers, and to form part of Volume 29 of the Transactions.

facilities consisting mainly in the provision of a better crane service for handling the work.

4 The principal reason why power is not used to a larger degree in foundry work arises from the fact that few foundries are so designed that the means at hand can be used to the greatest advantage. Machine molding is limited in its applicability to castings which can be turned out in sufficient quantities to justify fitting up for them. Power can be used for nearly all classes of green sand work, and once the proper fixtures for its use are available it will be found of service in many ways. The foundry crane of today is a vast improvement over that used in the past, but in the matter of improved crane service, not only the foundry but the machines shop as well, suffer a diminished output per square foot of floor area. Molding machines, cranes, chipping chisels, grinders, the blower and the cupola elevator are the usual limit of power service in the foundry. A few columns, roof trusses and siding, a crane with its runway, possibly a few jib cranes, a cupola with its charging platform, elevator and blower, some core ovens and a little industrial track are dumped down in a vacant lot and called a foundry. A rough neck carpenter knocks a few flasks together and sand is spread on the floor; just as soon as some pig iron, limestone and coke, etc., are delivered the plant is in running order. The machine shop is usually very carefully designed.

5 The crane service of a foundry is its vital point. There must be crane capacity to handle the heaviest piece to be made, but at the same time it is necessary to bear in mind the fact that there are a number of medium and a greater number of light pieces, to be turned out for each heavy casting. A single crane can serve only one floor at a time; the others must wait, in fact two or three floors are often waiting on the crane and must take their turns after the crane has finished handling a load of less than one-sixtieth of its capacity. This scene is not uncommon in the foundry, and that they were "waiting for the crane" is often the excuse for molds left over for the next heat.

6 The bridge traveling crane is a most useful machine but it cannot be in two places at the same time and as yet no successful method has been devised by which two of them can pass each other either on the same or on different levels, in fact the use of bridge traveling cranes on two levels only adds to the expense and does not supply any advantages over those cases where all of the bridge cranes are on the same level. The jib crane is limited in usefulness as it cannot serve floors outside of its radius, but a number of light

column jib cranes, arranged so that they can be set up and transported from place to place as needed, are very serviceable. This can be accomplished by placing permanent pintle bearings on a number of the columns and by designing the jib cranes so that they can be handled from point to point. The traveling wall crane affords the most satisfactory method of increasing the crane service without interfering with the bridge travelers above, and the column jib cranes below its level.

7 The electric motor offers the most satisfactory method of operating hoisting machinery. This arises from the convenience with which electricity can be delivered to these machines by means of sliding contacts. A further advantage lies in the close control of the movement which is essential to the gentle handling and accurate placing on the molding floor; another distinct advantage of the electric hoist is its ability to hold the load stationary for an indefinite time.

8 High hoisting speeds are undesirable, in fact the tendency is to get the hoisting speeds too fast in most shop cranes, high speeds being of service only in the handling of bulk materials and package freight. In the foundry a speed of ten feet per minute with full load is ample for heavy work and speeds exceeding twenty feet per minute are sufficient for the lighter hoists. Positive and uniform motion is necessary in handling copes and the sudden start of the ordinary air hoist spoils a great many molds. This sudden start occasionally occurs with electrically operated hoists having an improperly designed controller.

9 One of the important advantages of the electrical distribution of energy lies in the fact that only the exact amount of energy is transmitted and there are no stand-by leakage losses to cause expense. The occasional grounds which appear on the circuits can be taken care of readily and if the best modern methods of wiring are used very little trouble is likely to occur from this cause. A good quality of insulated wire, run in some form of metal conduit should be used; wooden molding should be avoided. The marine type of receptacles are most satisfactory for foundry service as the water-tight cover supplied with them is equally efficient in keeping out dust and dirt. These receptacles should be installed liberally as it is a great convenience to be able to get power just where it is wanted.

10 Another point of no small value is the kind of flexible connections supplied. These are often simply of lamp cord and are more or less of a nuisance, particularly when they get on the floor, where they are liable to be cut by a shovel, etc. Flexible metal tubing

makes a first class protection for such connections, particularly for those which have to carry several horse power. Connections of this size will be required where portable tools are used.

11 There are a number of good makes of electric motors on the market and some that are not so good. A first class standard motor is desirable, and in equipping a plant it is better to have all of the motors of one make, particularly those of the same size. A little attention to this point will greatly reduce the amount of money it is necessary to invest in spare parts. By a standard motor is meant one which has been made on manufacturing lines in large numbers. In addition to these there are a number of concerns building special motors more or less suited to their special requirements. The designers of such motors are handicapped by the fact that they are not able to avail themselves of the experience gained in the manufacture of a large and varied line. The street railway type of motor frame, or one which is split on an angle, having two poles or one pole in each portion of the frame is the most desirable, owing to the facility with which it can be opened up in cramped places for changing armatures or for other repairs. These motors are of the enclosed type and have been developed to work under conditions which would discourage the ordinary machine. The manufacturers of these motors often style them as "very rugged" which is an insult to the workmanship and designing ability which has developed these desirable types of machines. Another feature of such motors is the method of lubrication, in which the car box journal has been studied and improved. Lubrication is often neglected by careless operatives and while any machine is better for a little attention, these motors will stand up under poor conditions.

12 Molding machines are generally operated by compressed air, but hydraulic power is used with some machines. Compressed air is elastic and this is a disadvantage for many operations, as any alteration in the load causes a corresponding change in the position of the actuating plunger or piston. Some compressed air hoists have been designed with a governor device that regulates their speed of action, but it is impossible to avoid the troubles due to the elasticity of the air. Another disadvantage of compressed air machines is the large size of the hose connection required, which is more troublesome to care for than the smaller flexible connection to an electric motor. Compressed air however is very useful in cleaning out pockets in molds and for power ramming machines; for the latter it presents the only successful driving power. These machines are not as widely used as they might be, and where it is desirable to avoid the long air hose

connection, a portable motor driven air compressor can be used. The bellows and torch, for blowing out and skin drying the sand, can be avoided, the former by using the air hose with special nozzles, the latter by arranging some sort of a heating device close to the air hose nozzle. An electric heating device might be serviceable for this purpose.

13 As generally installed, with a central compressing plant, the use of compressed air requires an expensive transmission line and in addition, it is impossible to avoid leakage in the joints. Compressed air leakage does not show, and the pipe lines for this purpose, as usually constructed, are designed to remain tight only long enough to pass the acceptance test. Leakage is a continual drain on the system, and shows up in the amount of coal consumed. Except in the large sizes, air compressors are steam eaters like steam pumps; for this reason the small electric driven air compressor presents numerous advantages, as it consumes no power when out of use and, if portable, avoids the long pipe line. The disadvantages of long air lines are well illustrated by the fact that in some of the big excavating contracts it has been found very advantageous to install a steam driven electric generating station at a point where fuel was available from a railroad siding, and transmit electric power to the compressor station located on the work, thus avoiding the losses of a long pipe line or fuel haulage.

14 Hydraulic power is but rarely used in the foundry. It has advantages for some lines of work. Water being non-elastic, comparatively speaking, it supplies a positive pressure, and while the hydraulic machine can be stalled, it is impossible to break it by legitimate methods, when it is properly designed. The pressures carried in hydraulic systems range around 500 and 1000 pounds per square inch; where higher pressures are required in certain machines they are obtained by the use of intensifiers. The most serious disadvantage of hydraulic service systems occurs only where swinging joints are required to convey the pressure and waste water to and from moving machines, as cranes, etc. In the machines themselves the glands are like all other glands, troublesome to maintain, and are often pulled up so tightly that they greatly reduce the efficiency. The controlling valves also give a certain amount of trouble. The most of the trouble with hydraulic systems arises from the use of dirty, gritty water. An illustration of the advantages of using a clean fluid occurs in the hydraulic wheel presses in which the same fluid is used over and over again, these machines cause very little trouble from leaky glands. High pressure hydraulic systems are

however expensive to install, and it is extremely probable that the best method of utilizing hydraulic power will be to use an electrically driven pressure pump with its accumulator installed close to the floor upon which hydraulic molding machines are to be used. This would reduce the required amount of pressure and waste line to a minimum. Necessarily this small hydraulic plant could not be placed in the foundry itself but a small pump room would be a requisite.

15 Steam power was at one time the only motive force available and was either transmitted to those places in the foundry where it was required by means of belts and shafts, or small engines were used, driving the different machines by belts. In some cases small gas or other explosion motors are used in a manner similar to the early steam motors. Owing to the fact that small engines are not economical and have several other disadvantages which are familiar to all who are posted on foundry operating conditions they are not considered as desirable as other kinds of motors. The steam hydraulic crane and elevator, both of which operate on the same principle are two of the most satisfactory machines devised for foundry service, because they are very simple and for that reason it is practically impossible for the most careless operator to damage them, except by the most studied neglect. One of the bad features of any transmission system which deals with moist elements such as water, steam and sometimes compressed air, exists in their liability to damage in cold weather by freezing. This danger has to be very carefully guarded against in temperate and cold climates, during the night and on all occasions when work is interrupted. To guard against this trouble some form of heat insulation is required.

16 As to which is the best power to adopt, depends in a large degree upon the local conditions affecting the plant, and by studying such conditions much better results can be attained than are possible by off hand decisions. A harmonious installation works more smoothly than a miscellaneous assortment and, in addition, the design should take into account the future growth as a possibility, this matter being often left out and resulting in endless complications when extensions have to be made. Because the largest part of foundry power requirements are intermittent, it is extremely probable that electrical methods offer the most economical solution of the question, but against this the question of maintenance is often of more importance than the economy of operating expenses due to cheaper power.

17 The class of labor employed in many foundry operations is not possessed of any amount of mechanical skill or electrical knowl-

edge and for this reason it is advisable that the motive power portion of the equipment be as nearly "fool-proof" as possible and of the simplest possible construction in order that it may not be damaged by misdirected zeal. The use of electrical power necessitates the employment of one or more men to look after the motors, depending upon the number used, or else a considerable portion of the minor repairs must be made by outside help. Where the foundry is operated in conjunction with a machine shop the matter of maintenance becomes more simple. With steam, compressed air or hydraulic machinery the question of maintenance is not of such a complicated character as with electrical machinery, owing to the fact that it is much easier to get men who have some primary ideas and break them in to the small repairs required to keep the machines in operating condition. And with the exception of the most extraordinary break downs, such machinery can be restored to working order by the use of the facilities ordinarily available in the vicinity of a foundry. This however is not always the case in regard to electrical machinery, though since the uses of electrical machinery are extending so rapidly a time will be reached when the question of repairs will be as simple as it is with other types of motors.

COLLEGE AND APPRENTICE TRAINING

The Relation of the Student Engineering Courses in the Industries to the College Technical Courses

By JOHN PRICE JACKSON, STATE COLLEGE, PA.
Member of the Society

Near the year 1880 a new spirit in collegiate education had begun to grow vigorously. A few institutions previous to that time had been established in accord with this spirit which maintains that a college should prepare a man to do his duty successfully in any of the various pursuits of life, and not only in what are termed the "learned professions."

THE MORRILL LAND GRANT ACT—ITS TENDENCY

2 The greatest impulsion toward a practical and useful form of education for the bulk of the middle classes of the people was probably the now well known Morrill Land Grant Act passed by Congress in 1862 providing for the establishment of State institutions, the primary object of which was to be, "without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the Legislature of the State may prescribe, in *order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life*."

3 The wisdom of this act was not generally appreciated for twenty or more years after its passage, and even at the present time, its full

To be presented at the regular Monthly Meeting, Tuesday evening, October 8, 1907, of The American Society of Mechanical Engineers, and to form part of Volume 29 of the Transactions.

fruitage is only beginning to be harvested. Under it colleges were established in nearly all the States of the Union under the partial support and direction of the National Government, having as a fundamental constitution the passage of the Act quoted above. Even as late as 1880 and 1890 these institutions were considered more or less in the light of manual trade schools by a large element of the educated classes. They have thriven so successfully, however, during the last two decades that not only did they take position as high types of educational institutions doing a magnificent service, but the principles which actuated them proved so vital that all of the best institutions of higher learning in the country have been materially molded by the effect they have produced; indeed, today the first and primary object of all well organized colleges is to prepare men for a life of usefulness rather than for the purpose of giving them culture and polish.

4 This attitude, or spirit, which has been thus induced, is filtering down into the lower branches of education as evidenced in the manual training schools and many of the high school courses which are eminently fitted to prepare young men and women to perform efficient service in maintaining our present complex civilization. The same spirit will reach still further and will quicken the grammar and even the primary grades of education. Though the "three R's" will of course remain the essential basis of all primary education, the new motif will weave around and through them a training in the observation and understanding of simple natural phenomena which will do much to increase the usefulness and happiness of the great masses of the American people.

THE EARLY COLLEGE MEN AND THE INDUSTRIES

5 The earlier institutions, from about 1850 to 1880, which dealt with higher technical instruction confined their work largely to what is called civil engineering and for that reason it will be found that the civil engineering staffs of the railroads of the country are, to quite a large extent, and have been for many years composed of college men, but the manufacturing and similar industries of the country are even yet extensively officered by men who have had to obtain their necessary training through individual study. When the use of electricity became an important factor in our daily life about twenty-five years ago, the need for brains trained in the mathematical and physical principles underlying the use of electrical phenomena became so great that the colleges prepared to do so were

forced to furnish adequate courses in these subjects. It will be found, therefore, that the electrical industries are very largely controlled by college bred men especially prepared for their work. In the mechanical industries—which require fully as much preparation—and in the mining, metallurgical, marine, and steam industries, the movement has been much slower, but at the present day it is assuming a rapid growth. Probably of all these professions that of mining has lagged behind most in demanding highly educated officers.

6 The relation between the colleges and the industries during the period from 1880 to 1890 was a critical epoch, so far as relates to education in this country. At that time, when a young man was graduated from a technical college course he was, to all visible evidence, less desired and useful to the industries than if he had gone into the shop and taken an ordinary apprenticeship course for four years. As a matter of fact, in order to get a start at all, such a young man by necessity was compelled, except in unusual cases, to apply for work without permitting it to become known that he was college bred, otherwise he was foredoomed to failure. If he succeeded in obtaining a position, but afterward it became known that he was a college graduate he was placed under a serious handicap of prejudice. On the other hand, if his educational advantages did not become known, the chances were strong that he would forge rapidly ahead of his fellows in his work and quickly take a position of responsibility and control. At that time the need of a college bred man was not so insistent as at present, but even then machinery was growing more complex and the call for power units of increased size was becoming urgent, both on account of higher speed of travel—railway and steamboat—and on account of the larger production machines which the industries were rapidly adopting; thus, even then the need of a greater number of well trained brains was becoming imperative. At that time the educational preparation in the sciences was to a large extent in an experimental stage, but a good foundation in mathematical reasoning and the fundamental principles of physics dealing with dynamic and static forces were being taught in a number of institutions and the men who were being graduated were not badly prepared to step into the industries—at the bottom of the ladder. One of the difficulties experienced by employers at that time was possibly due to a lack of appreciation on the part of the young men themselves that notwithstanding their four years in college it would be necessary to start at the bottom and learn from its incipiency the business they were about to enter.

THE CONNECTING LINK

7 Early in the last decade when our industries were rapidly growing in complexity, this call for trained men became so urgent that it was necessary for the managers of the industries to take measures to supply the need. A survey of the field showed that the young men who were being graduated from the scientific colleges, then in comparatively small numbers, were not fitted to take positions of responsibility, and it seemed at that time doubtful whether such men had or could obtain the practical cast of mind which is essential to technical work. Certain far sighted managers connected with the Westinghouse, General Electric, and Western Electric Companies, and other industrial concerns had been employing some of these men and were putting them through a more or less rigorous course of preliminary training with the idea of preparing them for usefulness to their companies.

8. An early step was described in a circular letter written in the 90's by the shop superintendent of one of the companies and sent to a number of the leading engineering colleges of the country. In this letter, the writer in essence stated that his company had decided to employ a number of newly graduated men each year at a low rate of compensation and would teach them the details of the business during a course of about two years. It was stated in the letter that the men who were appointed were to be considered as receiving scholarships, and it was hoped that the colleges would hold forth to their classes these positions as incentives to a high grade of work. Appointments were to be made strictly on the basis of the records of the young men. As stated previously, other companies were also taking this stand, in most cases in a less formal way. For eight or ten years such *student engineering courses* in the industries have been springing up in large numbers all over the country.

GROWTH OF THE MOVEMENT

9 It is the link offered between the technical colleges and the industries by these student courses in the shops and power plants with which this paper has to deal. This link lies in the mind of the writer as probably the greatest advance in useful education which the world has ever seen accomplished in the same space of time. In the old days the boy who graduated from a literary or classical college and who found himself unfitted for the learned professions was apt to become a pauper and a burden upon the community; and, as already said, even the technical graduate had great difficulty at first in making

himself useful and valuable. Today, on account of this new type of post graduate industrial education, every young man who has received his bachelor's degree, and who has a fair modicum of brains and common sense, has fields innumerable open to him which lead, possibly by slow steps, but surely, to positions of responsibility and usefulness which carry with them in the end excellent rewards to men who give energetic, and studious service.

10 From 1872, about ten years after the Morrill Act was passed, until 1887 the technical courses in the colleges were being developed. The next ten years was a period during which the industries and the colleges were endeavoring to adjust some means whereby a very distinct and apparently insurmountable gap between the work of the two could be bridged; and from about 1897 to 1907 may be considered a period during which the industrial companies were developing the student engineering courses which were to serve as a bridge and the time during which the colleges were modifying their courses so as to meet this development.

IDEALS IN STUDENT ENGINEER COURSES

11 The student engineer courses of the industries, where they have been fairly well established, at the present day extend usually over two years and enable the young graduate actually to perform the processes with his brain and hand on each important operation in the establishment, whether it be the factory or power plant. Possibly the quotation of statements from men directly in charge of the young graduates would at this point aid in making clear the ideals which have underlain the development of the work to the present time.

12 The quotations I have selected are from a file of letters of Mr. A. L. Rohrer, General Electric Company, Mr. Chas. E. Downton, Westinghouse Electric and Manufacturing Company, Mr. A. T. Bruegal, Fairbanks Morse and Company, N. C. Bassett, Allis Chalmers Company, C. E. Scribner, Western Electric Company, J. M. Gilmore, formerly of the Stanley Electric Company, The Union Switch and Signal Company, Baldwin Locomotive Works, The Pennsylvania Railroad Company, and others.

13 Portions of one statement are as follows:

Very early in the history of the company it was found desirable, or rather necessary, to train its own men and at first they selected bright, intelligent young men, who, in many cases, had had some mechanical experience. Later on, when colleges began to shape their work so as to include more and more electrical work and, finally, to put all this into a regular course of electrical engineering, the men

were put through a system of practical training. This work finally led up to what was then called a student's course, because practically all the men who entered had either been students or had graduated at some one of the technical schools or colleges. At one time this work was supervised by a man who had great confidence in the English scheme of practical training whereby the men paid a certain stipulated amount each year for the privilege instead of receiving a salary. It turned out to be more or less of a failure for the reason that many a bright man was debarred from entering the course on account of the fact that he had either paid his way through college or could not afford to borrow money to make payment to the company.

It was then changed and men were employed regularly for work in the testing department. At one time they began at the rate of 8 cents an hour. After awhile they were paid 10 cents when entering, and later 12½ cents and 15 cents, their rate of pay being advanced from time to time as their services warranted.

During all this period great stress was laid upon the work in the testing department. It was believed that these men were best fitted for testing work as it was following along the general line of their laboratory work in college, but opportunities were offered at different times for certain of the men who had shown special ability to get some training in the mechanical departments. At one time the men who were selected for positions in our engineering departments were given several months training in our shops, then sent to the drafting department for several months, and then into the office of one of the designing engineers. We are now giving all the men who enter the testing department a short period of training in our shops as soon as they enter our employ; that is, the work which they do first is in the mechanical departments as preliminary to the work in the testing department. It is believed that from ten to twelve weeks can be spent to good advantage as it enables them to obtain an insight as to how the apparatus is put together. The principal part of their work, therefore, while in the shops is on assembling work.

We have arranged a schedule which we follow as closely as conditions of production will allow, but the men all understand that if necessary they must remain in one section much longer than the schedule calls for. If, however, the men are transferred in accordance with the schedule about twenty to twenty-two months are required to get all the training. We really put ourselves to considerable inconvenience in transferring these men, because about the time they become proficient in one class of work they are transferred to another section, but we feel that in the end we are repaid for so doing.

We do not ask them to enter into any contract to remain with the company a specified time. They are treated in a broadgage way, and all we ask is that they spend sufficient time with us to become familiar with all the apparatus and to be really good representatives of the men who have been through the testing department. We never stand in the way of a young man who has an opportunity for a good position outside; in fact, we are just as anxious to have good men with our customers as we are to retain them in our employ. There is nothing philanthropic about this as there are in the employ of a large percentage of all the electric railway and electric lighting companies men, who at one time or another have been in our testing department. I think I am safe in saying that they are all good friends of the company and realize that the time spent here has been of great advantage to them.

14 Another man describes the work in the student engineer course under his charge as follows:

Only a few years have passed since the college man was looked upon askance by the then self made practical engineer, and the young man about to start in the profession had great difficulty in gaining recognition from any one. No one of that day wanted a young man who had "received his knowledge from books."

Another reason not expressed, but nevertheless felt, and proved by careers of prominent engineers of today and the great demand for technically trained men, was that the theoretical man with practical experience would eventually become an important factor in the organization and, hence, a keen rival.

Industrial enterprises, where results mean dividends, have for some time recognized and taken advantage of the opportunity to build up the directing force with men of this caliber.

The company has organized its engineering apprenticeship system for the sole purpose of furnishing recruits to departments having vacancies or where there is need for additional help.

Seventy-five per cent of the men will be given positions of responsibility in the company's service or be placed by the company in electric lighting or railway work, which is quite to the company's advantage, since the young men will be in the field with a thorough knowledge of the products manufactured here.

I believe it is quite generally admitted by heads of schools of engineering that the young man leaving college is rarely, if of any, of immediate service to the profession. This, we know, has been our experience.

The apprenticeship course not only gives him an opportunity to gather information relative to engineering and factory methods, but it places him in a position to be observed by others—a sizing up process as it were—which gives us possession of information regarding his personal qualities and characteristics.

Our course is divided into three sections: *a* shop or actual manufacture, *b* engineering or designing, etc., *c* testing or operating. This, we have found, gives the broadest experience and a sure method for the selection of men for specific lines of work.

The course in the shops is scheduled by departments, no attempt being made to specify any particular work. This is left entirely with the foreman in charge, who will assign work in a way to accomplish the best results. Any one showing superiority in the use of tools will be given a task of value proportionate to his skill. A great portion of the information gathered is obtained through observation.

Until quite recently no concentrated effort was made to develop men for any department other than engineering and erecting. Now we are including manufacturing, selling, correspondence, and in fact every department within the organization.

15 Another employer writes:

The students will be subject to the conditions of the other workmen where they happen to be placed: they must accept the same hours, regulations, piece-work prices, overtime allowances, etc. They will have, however, one assurance which other workmen do not have, *viz.*, that they will not be laid off on account of ordinary periods of slack work, and in return for this consideration they will be expected not to withdraw until they have finished the course.

At the completion of the course, the obligation on both sides will be at an end and the men must be prepared to look out for themselves, because the company will further employ only such of the graduates as it may need as engineers and assistants in its various departments.

The following will be the approximate distribution of a man's time, working in the shop, the first year.

Generator and motor assembly	4 months
Switchboard assembly	2 months
Transformer assembly	2 months
Winding and insulation	2 months
Annealing building	1 month
Inspection	1 month

The second year will be spent in the testing department.

Generator testing	4 months
Motor testing	2 months
Transformer testing	2 months
Instrument testing	2 months
Arc lamp testing	2 months

The last six months' time will be spent either in the outside construction or commercial or drafting department.

It must be understood that the company does not bind itself strictly to these schedules. Occasion may sometimes require that a man's time in one department be shortened or lengthened: and a student may omit some departments entirely, when his services are wanted in more advanced work: but the student's own wishes will be consulted as far as possible.

Applicants must be graduates in electrical or mechanical engineering from institutions of good standing. They must secure a good recommendation from the man under whom they have done their practical work in electricity at school and a good reference from a previous employer if possible.

Applicants must answer satisfactorily questions as to age, descent, physique strong or indifferent, school or college course, record in studies, record in laboratory, whether it is the intention to complete the student's course as outlined, what experience he has had in electrical work outside of school, how soon he could begin work in the department named, what is the latest date that would suit the applicant.

16 Some of the items in the circular of another company are:

The applicant must be a graduate of a school of technology. Students shall serve for an equivalent of two years of 2750 working hours each.

The company does not wish all the students in each year's class to start in at the same time, but prefers rather to spread them out over a space of several months, from June to October. In making application for the students' course, applicants will therefore say when they prefer to begin work. Their preferences will be followed as far as possible, but the company reserves the right to fix the dates for beginning work.

At the end of the entire term of service, for the faithful performance of his duties throughout the course, each student will be paid a bonus, but this bonus will be reduced *pro rata* for students who may be permitted to shorten their course and who may then be taken into the company's regular service. No bonus

will be paid to students who leave the company's service before the end of the course, either the full course or as the course may be shortened by the company, or who may be discharged for cause.

The company reserves the right to discharge any student at any time for misbehavior, unfaithfulness, disobedience of orders, improper conduct or continual failure to comply with the rules of the company.

During the first quarter year, or 685 hours, students will be considered as on trial and may be discharged during or at the end of this period if the company should be of the opinion that the student is not qualified to continue the course, or for personal or other reasons is not desirable as an employee or as an associate of other students.

Students shall be subject to all shop and office rules.

After having satisfactorily completed his full term, or such shorter term as the company may decide upon in any individual case, the student will be given a certificate certifying to the same, which will be signed by the superintendents of the works where he has been employed, and the heads of other departments in which he has worked.

17 It is seen from the letters and the descriptions of the courses that they are laid out by practical men for the purpose of training the young graduates for positions of responsibility. In all cases, so far as the author has observed, the student is passed from department to department until he has fairly mastered the fundamental details of the entire business. In most cases, in addition to shop work, erecting, etc., the man also must pass through courses in the designing rooms and the commercial departments. Though schedules are arranged they are not always followed out exactly, as in some cases a young man shows proficiency in certain lines of work, while in others he needs extra time, though it is to be presumed that the time allowance for each division of the course is proportioned to meet the requirements of the average student. To all appearances the schedules made out for the men are based purely upon what will form the best training, without special regard to what will bring the best labor return to the corporation. Thus far the student engineer courses seem to be fairly well established at quite a number of places.

STUDENT RECORDS

18 One of the important features of these courses is the keeping of systematic records of the students. Probably the most satisfactory method is to hold the foreman of each department in which the students are employed responsible for the records of their departments. These records should be turned in weekly to the superintendent of students whose duty it is to keep them on file and enter the individual reports of foremen upon cards made to cover the entire

course. Such a system places the foreman much in the position with reference to these young men, as their instructors were while in college; it has the advantage not only of giving the officials of the company full information, but tends to interest the foremen in the students and to lead them to do all they can to maintain this practical post graduate college work.

19 The following record is a general form such as is kept by the General Electric Company and shows a satisfactory arrangement.

NAME	CHECK NO.	ENGAGED	LEFT
Doe, John	23	3-21-05	3-22-06

Section	Time spent in section		Day or night	Technical ability	Industry	Promptness	Accuracy	Energy
	from	to						
Marine.........								
Government...	3-21-05	5-21-05	D	B	A	A	B	B
Induction Motor								
Slow speed	5-21-05	8-20-05	N	B	A	A	A	A
Floor..........								
No. 16.........	8-20-05	12-17-05	N	A	A	A	A	A
Transformer ...	12-17-05	3-22-06	N	A	A	A	A	B
Railway Motors.								
Turbine........								
Special........								
No. 23, etc								
Berme bank....								
Calculating.....								
Switch-board...								
Resistance meas								

Address, 320 Hulett St. Home, Albany, N. Y.
Notify Mr. John Doe, 23 Hawk St. Home, Albany, N. Y.
Nationality: American. Age: 22. Class of work, special.
College: Eureka College, 1904.
Inst. Books spec. 732 OK. A. C. D. C. Trans. Tur.
Rheo. C. B.

The grade reports are made by the foremen of each department, and are entered upon the young man's card in the record file. The grades are specified in letters and A is a higher grade than B. On the reverse side of the card are columns for absences and their causes, rates of compensation, work desired, and positions held by the student after leaving the course.

20 Such a system as this shows quite clearly the capability of a young man and enables those who are employing men on the regular staff of the works, or those who are sending them to customers, to make selections intelligently. It might be desirable to add two columns to those given upon the record card above, namely, neatness and tact.

21 In the early history of these courses apparently little system was applied in the following up of the young men, and there was danger of the boy who did not have much self assertiveness becoming lost in some department where he had learned to do some one thing to the satisfaction of his foreman. In all such cases, where the young man had sufficient aggressiveness to go to the proper officials of the company, he was usually able to have the difficulty rectified. Nevertheless, the lack of system in this regard was a serious weakness, both from the standpoint of the corporation and the student. For instance, in the early days, I frequently had young men who were pursuing the student courses write me stating that as far as they could observe, the result of their best endeavors was apt to go unheeded and their chances for advancement were slim. Of course, this was an exaggerated feeling of the young men, thrown as they were among thousands of skilled workmen, and not a true statement of the facts.

22 On the other hand, in student courses which lacked careful centralized supervision and a system of individual grading it was difficult to advance the young man with discrimination and judgment. This frequently gave the showy youth an advantage over the diligent and thorough workman.

23 Not only should such records as spoken of above be kept, but the foreman should be made to understand that it is his duty to see that the young men have become sufficiently well trained in his department before they are permitted to be transferred to other work. In the case of students of a special aptitude, the time required could well be shortened from that of the average schedule, while in other cases it might be necessary to give double the ordinary length of time. This, in fact, is similar to the method taken in colleges: thus, if a young man fails in applied mechanics while pursuing the subject with regular classses, he must either repeat the work in another class, or employ a tutor to take him over the subject again. A man, who after having thus attempted a subject is unable to show the proper preparation, had better be advised to change his collegiate course to some other line. Likewise a young man working in one of the departments of a student industrial course should be followed just as carefully and if he shows himself incompetent to learn the business, he should be promptly dropped, or transferred to different phases of the corporation service.

THE FOREMEN RESPONSIBLE—MENTAL TRAINING

24 In connection with this subject of keeping the records of the young men which, more or less, involves the development of the fore-

man into the capacity of an instructor, I wish to suggest an extension of this corporation teaching which has not always been developed to its greatest possibilities. It would be wise, both for the boy and for those employing him, if the foreman or superintendent should assume even more of the attitude of instructor than is now the case and require the young man to be prepared to regard questions about his duties. Thus, for instance, a young man might be working on a transformer test and obtain entirely satisfactory and accurate results, but at the same time he might fail to expend the energy necessary to think out and understand exactly why and how the various steps were taken—it is far easier merely to follow directions. A few pertinent questions from the foreman would quickly discover such lack of depth upon the part of the student, and likewise the knowledge that he was to be so questioned would undoubtedly spur him on to reach deep into all the work he had in hand. Also in the machine shop a few questions as to the use of the cutting tools which were being used and concerning the character and strength of materials in the product, etc., would tend to develop a quality of observation which would be of the greatest service, not only to the student, but to the corporation after the man had reached a position of responsibility. This method could be developed to quite a high state of efficiency with advantage to all concerned, including the foreman. It would be well to let the foremen know that failure to follow up and get not only material but also mental results would be one of the bases upon which he himself would be judged. Training of this character would give additional data for record which would frequently develop the strength of a quiet man over that of his fellows, without which he might not for many years be discovered.

STUDENT ENGINEERS' CLUB

25 In the engineering apprenticeship courses we come to another phase which, I believe, is equally full of possibilities for improvement. Thus, some of the larger corporations which have had student engineer courses established for some years have clubs for the men where they may meet together socially and also where lectures of a technical nature designed to be especially helpful are delivered. The Westinghouse Company, I understand, is at present erecting a very handsome edifice which is to subserve this purpose. Up to the present time, so far as I know, such educational work has been voluntary upon the part of the young men. An energetic, active, ambitious boy will obtain all that is possible, while many another good

fellow who needs a little spur will neglect this part of his duties. These clubs are most useful in that they furnish a place where young men can get together with the more experienced engineers of the company and discuss problems of engineering without restraint. They also furnish a social side of life which is delightful and which tends to improve the *esprit de corp* of the whole student body. This latter is essential to the success of any corporation.

REQUIRED MENTAL WORK

26 A further great step in this important educational movement which we are considering, I believe, will be to extend the mental work much further. The voluntary leaders and the informal discussions of the clubs will undoubtedly continue, but in addition there will be compulsory work. Courses of study lying side by side with the practice in the shops and factories will be laid out and will be directed by men thoroughly capable, not only from an engineering but also from a pedagogical standpoint. The corps of instructors, headed by a trained teacher of engineering, will be drawn from the suitably prepared men in the engineering departments of the corporation. The young men will be required at stated intervals, having been set mental tasks parallel to their practical work, to appear at regular class periods before the members of their corps of instructors and take such quizzes and receive such special explanations as may be found desirable. Such an advance in the educational movement as this must perforce appeal to every educator and will, I believe, appeal to the practical engineer. A young man will not be left to himself to permit his mind to wander away from the consideration of the problems which will transform him into an efficient engineer, but he will be under a constant spur tending to lead him to improve his mind in a way to insure his future usefulness. It may be argued that too much of this kind of study, which of necessity will be done after a day's work would overburden the boy and in that I am fully prepared to agree; but it is not necessary to carry the work to that extent. Such a mistake would be made only by an over enthusiast who lacked a knowledge of pedagogical principles, and it is well here to state with emphasis that this movement is entirely too important to the industrial classes of the United States and is too much in the line of pure education for the pedagogical side to be neglected. I believe that future development will find men in charge of this great work of preparation who will be engineers trained not only in the sciences, but in the theory of teaching as well. Even

in our technical colleges it has only been within a few years that the importance of the engineering instructor being a trained teacher has become fully understood. Now, the call for such preparation is evidenced by college presidents giving thought to the selection of men with reference to their teaching as well as their practical ability. I have seen many cases where men, thoroughly successful as designers or in other positions in the industries, have utterly failed when endeavoring to impart their knowledge to college classes and to furnish the inspiration necessary to cause their men to get the best out of their studies.

27 In this teaching, a great amount of time need not be taken from the regular shop work since these young men are college graduates and they are, therefore, fully enough developed to carry on post graduate study with comparatively little spurring or explanation upon the part of the instructor. Possibly, a meeting by the instructor—preferably with each man individually—once a week would be sufficient to lay out and comment upon the work to be done and to question upon that already accomplished.

WILL IT PAY

28 The crucial test of every innovation in the industries is, of course, the question, will it pay? The courses developed as they are to the present day seem to be worth while; at least such is the bulk of the evidence that has been obtained from the somewhat extended investigation of the writer. It seems that the courses which pay best, to recapitulate some of the statements given previously, aim primarily to prepare men for high grade engineering duty; the return in labor received during the course being held as a secondary consideration. Such courses employ only college graduates—giving preference to those technically trained—at a wage upon which a young unmarried man can exist without loss of self respect if he is not extravagant. Sometimes a bounty is paid at the end of the course, but its utility is questionable. The length of most of the successful courses is about two years and during this time the student is made more or less familiar with the details of the entire business by being moved from department to department. The foremen of the departments are expected to teach the processes to the students and make frequent grade reports to a central authority. Careful records are kept of the character and standing of the students. Clubs, lectures, and publications are furnished, largely at the company's expense, for the purpose of teaching them and of inspiring them to an enthusiastic interest in their work.

29 Long time contracts are, as a rule, either not called for or are largely a formality, as students are not wanted who do not care to stay on their own volition and who are not interested in and loyal to their work.

30 . Such courses as these seem to give satisfactory returns, financially, by furnishing a loyal body of highly intelligent engineering talent for the managing and engineering corps of the organization.

31 Will such courses pay when they become still more collegiate in their nature by adding required scientific mental study, as suggested earlier? Though it is understood that the study would be carried on in the evenings, from one to three hours a week would be given by each student to his instructors and a large amount of the company's time would be expended by the instructors themselves. Experience is wanting to answer the question, though a school for ordinary apprentices, maintained by one of the western railways, bears somewhat upon it. This school is carried on with the aid of the instruction papers of a large correspondence school. Regular instructors have been appointed and time is taken from working hours for the class work. The foremen with whom the boys come in contact and other officials of the company join in highly recommending the movement, not as a philanthrophy only, but as an excellent business proposition. It is claimed by concensus of opinion that the added intelligence and interest of the boys more than pays the expense, while at the same time a body of unusually well trained workmen is preparing for the service of the company. In this school arithmetic, algebra, drawing, etc., are taught.

32 Suitable mental training will be less expensive to compass for the college apprentices than with the younger boys in the school just spoken of, and should yield even more beneficent results. The highly improved training obtained by those who are able to graduate from these improved courses should more than compensate for the slight *per capita* extra expense involved.

33 The instruction force could undoubtedly be kept in excellent condition by now and then giving some of the younger members a year's leave of absence for the purpose of teaching in the technical schools. This would be a mutual advantage to factory and school which could be augmented by such men exchanging positions temporarily with the regular college instructors. The Pennsylvania State College in its electrical department has already taken steps toward obtaining such teaching relations with the industrial companies to which it furnishes students, and it is believed that excellent results will follow.

ARE EXTENDED STUDENTS' INDUSTRIAL COURSES NECESSARY

34 It has already been shown that student engineer courses have grown to their present proportions on account of the positive need of men more highly trained than is ordinarily possible through the self education of the so-called practical man. As courses are today being inaugurated in various divisions of the industries in large numbers, their necessity in the present state of the arts seems fairly well established. But are not these courses now sufficiently advanced where found in their most perfect form? Is further expense as I have proposed devoting to their further development justified? The logical sequence of the growth of both industries and practical education in the United States for the past one hundred years seems to answer in the affirmative.

35 During the first part of the nineteenth century a man of ordinary mental strength could easily understand almost any of the industrial processes of the day. A farmer and his family could do their own manufacturing and could maintain their own transportation lines. The horse was the accepted source of power. Later at the time of the Civil War—the time of the passage of the Land Grant Act—industrial conditions had become more complex. The steam engine had become a common burden bearer and was already doing wonderful things. Our people were becoming less bucolic. Shops, factories, iron mills, railroads, telegraph wires were spreading over the country with unimaginable rapidity. Yet enough sufficiently well trained men to guide these budding industries came from the few unusual boys who worked their way unaided from the bottom to the top and obtained their scientific training incidentally. Technical schools were then little in evidence, but the need of something of that kind was beginning to be felt.

36 Consider now the present time. Compare, if you will, with the earlier period the vast railroad systems, the enormous steamships, the great power plants, the manufacturing establishments—each requiring the services of thousands of workmen—the gigantic mining operations, the intricate telephone systems reaching into every hamlet of the country. The change in the economic condition is even more remarkable than was that from the first to the middle of the nineteenth century. The technical college has come. The simple and practical engineers' collegiate apprentice course is here, forming and drawing together bands of technical men probably far out numbering and out classing in proficiency any earlier engineering organization in the history of the world.

37 But already the industrial complexity of life is multiplying so rapidly that a still higher class of brains must quickly be supplied. Every day gives evidence of this fact. For instance, as this is being written, the new steamship Lusitania is making a great burst of speed which will probably lower the record across the Atlantic by several hours. But to do so she had to have within her hull a power plant large enough to light and heat a large city. This is but a single instance of the rapid progression along all technical lines. Every appearance indicates that during the next few years there will be an insistent call for many men of the highest mental preparation. These men must be partially trained by the industrial interests themselves, seemingly in much the manner I have outlined in this paper. It will pay to begin this work now.

THE DUTY OF THE TECHNICAL SCHOOL

38 The argument may be maintained, and with some show of plausibility, that the government should bear the expense and trouble of educating its people. So far as possible, I believe this is so, but the college or university must, to a large extent, confine itself to the teaching of the fundamental truths of nature and cannot to any extent teach the details of each specific branch of industrial business. This latter instruction with much of the "theory" that accompanies it must be given in the shop, mine, or factory.

39 The college can do much to improve conditions by giving extended courses of five and six or more years as is done in the form of post graduate collegiate work today. But to encourage young men to thus further prepare themselves, the industries must offer some consideration. At present the six year college man usually starts with the same compensation and in a position of the same grade as the four year man, which is certainly discouraging and unfair. Such a condition is injurious both to the college and industries and should be rectified.

AMERICAN INDUSTRIAL SUPREMACY

40 When the whole social and industrial fabric of France had been beaten down and destroyed by one of her brilliant but disastrous wars, she rose in prosperity almost Phoenix like, largely through a system of practical education closely allied to her industries. Many other historical instances might be cited where such education has for a time made a nation a world leader. The spirit of the Land Grant Act and the close relation it has formed between education and the

industries has already done much, I believe, in giving the United States her strong position among the nations of the world. The leaven of that spirit will work much further by bringing these two elements into still closer accord, not only in the higher grades of education, as herein suggested, but also by the magnificent movement that is now just stirring our political institutions and which is destined in the form of a wide spread system of industrial education to prepare every man who works with hand or brain of every grade "to perform justly, skillfully, and magnanimously all the offices" to which he may be called. Let us hope that as the nation thus grows in industrial perfection, it may also grow in appreciation of pure culture and art.

DISCUSSION

A HIGH SPEED ELEVATOR

By Charles R. Pratt, Published in this Number

Mr. Orman B. Humphrey There are three essential elements which necessarily enter into all installations of passenger elevators, and these, in the order of their moment are: (*a*) *safety*, (*b*) *speed* and (*c*) *economy of operation*.

2 What pertains to elevators for high buildings must also be considered in the equipment of all passenger elevators, except that some of the sub-divisions of these elements of safety, speed and economy of operation must vary in their individual degree of importance when the elevator is intended for service in buildings of great altitude.

SAFETY DEVICES

3 At such minimum car speeds as are desirable in all high buildings we must eliminate certain types of safeties as being not only wholly unfit for use under these increased speeds, but positively dangerous. The safeties referred to are any and all types of sliding wedges, rolls or grips, or other devices which tend to check or stop the car suddenly in case of broken cables or excessive speed in descent. This leaves for consideration such forms of safeties as shall gradually and effectually, but not suddenly, check the descent of the loaded car in case of accident. There are various safeties of this nature, usually depending upon some form of speed governor and fixed governor rope, which accomplish this desired checking and retarding of accidental excessive speed by means of gripping the rails, and with the best of these we are all familiar. All devices which depend upon gripping a greasy rail, unless of the sliding wedge type having more or less sharp teeth to engage the rails or fluted rolls—neither of which can be used for high speeds, will sometime be found wanting; it is not unreasonable to state that the rate of retardation or checking of the car descent with these safeties is more or less variable and at times somewhat problematical. It is for this reason that other auxiliary safeties ought to be included in the equipment of all elevators.

4 Of the different safety devices in use at the present time, the one which appeals most strongly to the writer is that which depends, not upon clamps applied to the rails, but upon series of wires arranged with systems of retarders which in turn become engaged by dogs on the moving car in case of accident, thus gradually checking the speed of the descending car, and bringing it to a standstill without undue jar or shock. This wire friction device, like the Cruickshank safety, installed on the elevators at the new Hotel Belmont in New York, meets a demand which has long existed in elevator practice.

5 It is not well to depend upon any one device or type of devices, but rather upon several distinctly different schemes for checking accidental fall or excessive downward speed. In addition to various mechanical retarding devices, the best of which should form part of every elevator installation, there should also be a carefully designed air-cushion of at least one-fifth the total car rise.

6 It should be the duty of the legislature in every State to enact laws regulating the number and types of safety devices which should be applied to every passenger elevator. Such legislation should be very broad and cover the entire installation, as to material, design of equipment, car speed, etc. This has already been done to a certain degree in some States, but there is still much room for improvement even in those States already having such legislation.

SPEED

7 The second important question is that of reasonable speed, and under this head we must consider, not only the periods of positive and negative acceleration and actual car velocity, but also any and all methods and devices which shall facilitate the handling of passengers with expedition and comfort. The period of acceleration should be as brief as is consistent with safety, comfort and economy of operation. The stopping of the car should be accomplished within a running distance which should always be under positive and absolute control of the operator, and in good practice it must depend to a certain extent upon the velocity of the car when running at its highest speed. The maximum car velocity should never exceed 600 feet per minute. Legislation controls this in some States. Assuming a maximum 600 feet per minute for express service, it will generally be found advisable to adopt nearer 500 feet or even less for speed on local cars. The writer does not favor excessive car speeds.

8 Much can be accomplished in ultimate despatch by using cars of suitable size and design, and by perfecting the devices which form parts of the car and well enclosure, like those for opening and shutting the doors, as well as having ample door openings; also the facility and certainty with which the up and down signals can be understood by the car operator. It is impossible to deny that to a certain extent the element of safety increases inversely as the car speed. Therefore while all reasonable speed should be obtained, it should not be accomplished at the expense of the element of safety.

ECONOMY OF OPERATION

9 The economy of operation may best be treated under the different types of elevators, and owing to inherent faults, which appear in the installations in high buildings, the plunger elevator will be mentioned here only to condemn it. For moderate rise it may be well enough, barring the generally erroneous impression regarding its absolute safety, but in the modern high office building it has no place. This leaves but two standard and accepted types of which it is necessary to speak. The horizontal or vertical cylinder hydraulic, and the drum electric, machines.

10 Between the horizontal and vertical hydraulic cylinders there is little choice aside from the individual requirements of different installations governing the amount of room available for the elevator machine. It has been demonstrated that the drum type electric elevator is by far the most economical in operation under the varying loads which must necessarily be handled in high buildings, and the question is often raised whether the relative safety and speed of the hydraulic and electric machines may best be answered by calling attention to the increasing number of the latter type of drum electric elevators which are now being installed. The great improvements made in the past few years in developing the electric machine and perfecting methods of control make it certain that it will be used to the practical exclusion of all other types before very long, even in high buildings where it must meet the most rigid requirements for the highest attainable standard of safety, speed and economy of operation.

COLLEGE AND APPRENTICE TRAINING

By John Price Jackson, Published in this Number

Mr. W. O. Webber At the Erie City Iron Works, in 1889–1894, the writer established a system of apprenticeship in which the

apprentices were paid a fair rate of wages, sufficient to enable them to live properly on their own income, and in return they agreed in the apprenticeship papers that if the apprentice served his four years faithfully, at the end of his apprenticeship we would give him a set of signed papers showing that he had faithfully performed his duties as an apprentice; that he was a skilled journeyman in the particular line, or lines, in which he had served, and making him a present of $100.

2 This present, or bonus, was in no way deducted from his wages, but was purely and voluntarily a present from the company to the apprentice, to enable him to provide himself with proper tools, clothing, and otherwise the means of starting him out upon the road, if he so chose, as a journeyman machinist, to go elsewhere, or stay with us, if he so elected. As a matter of fact, all our apprentices stayed with us.

3 At the beginning of their third years, if the boys had proved intelligent and satisfactory, they were taken into the drafting room, and part of their four years' apprenticeship consisted of at least six months in the drafting room.

4 The fourth year was considered to be somewhat elective, *i. e.*, the apprentice was given the choice of remaining in the drafting room and completing a draftsman's course, going into the pattern shop and learning the essentials of pattern making, entering the foundry or of returning to the erecting shop where the greater part of his fourth year was passed on the testing blocks, making dynamometer tests and taking indicator cards, and adjusting shaft governors, setting valves, etc., or he could return to the machine shop proper, where he acted as foreman's clerk.

5 We also had other apprentices, for instance, in the foundry, who took nothing but an iron molding and brass molding course, excepting that they had the opportunity to work in the drafting room and learn drawings and pattern making; we had also pattern making apprentices who had an opportunity to learn something of molding. Boiler making and blacksmith apprentices, in the same way, were given opportunities to learn thoroughly all parts of their respective trades.

6 We found as a result that we had a splendid lot of embryo foremen on hand. Some of these boys are now proprietors of their own shops, and are invariably doing well. We exercised great care in their selection, and no applicant was taken who had not graduated at the high school, and who could not pass a pretty stiff examination in the three "Rs." The result was that an apprentice was found

to be the only person out of some thousand employees, including those in the office, who could do cube root quickly and intelligently.

7 We always had from a dozen to twenty applications on the books from high school graduates desiring to enter our apprenticeship system. As far as possible we took them in in the order of their application, their intelligence and other qualifications being equal, the only exception being that the sons of the employees of the company took precedence over outsiders.

8 These boys were encouraged in every possible way to perfect themselves in the theory, as well as the practice of their trades. The head draftsman established, on his own responsibility, but of course with our sanction, an evening school, to which the boys could go if they so chose. They were encouraged to ask questions, directly of their foreman or the writer, and in fact the writer made it part of his business to have a close personal supervision over the apprentices, which, he found, resulted in the apprentices being a pretty reliable barometer of the discipline and morale pertaining in the shops in which they were working. In other words, what a bright young apprentice doesn't know, and doesn't see, in the shop where he is working, isn't worth knowing.